Vol. L. No. 10

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INSTRUCTION IN MUNICIPAL GOVERNMENT for pupils in elementary and high schols is to be studied by a committee of the National Municipal League. Mr. Wm. H. Maxwell, Superintendent of Public Schools, New York City, is chairman of the committee, which also includes many other eminent educationalists. Further information may be obtained from Mr. Clinton Rogers Woodruff, Secretary of the National Municipal League, Philadelphia, Pa.

GASES IN A SEWER at Milwaukee, Wis., caused the death of three men on Sept. 1. Mr. R. J. Hickey, a sewer contractor, a Mr. Schunke, of the city water department, and a colored man, were in the North Ave. sewer, under the newly depressed tracks, when they were overcome by gas and died or were affected beyond recovery before they were rescued.

THE CHEAPEST GAS IN THE WORLD, it is claimed, is made by the municipal gas works of Widnes, England, and sold at from 32 to 24.3 cts. per 1,000 cu. ft. The works were bought by the borough in 1867, and now have a daily capacity of 1,500,000 cu. ft., and a total annual consumption of about 250,000,000 cu. ft. There are 5,822 consumers, of whom 3,745 make use of penny-in-the-slot-meters. The total cost of the works to March 25, 1903, is given as a little under $500,000, including the original purchase price. The outstanding capital is about $350,000, the balance of the cost having been paid off from the sinking fund and profit and loss account. A description of the works, by Mr. Isaac Carr, Manager, appeared in the "Gas World" for July 25, and was reprinted, with equivalents in American money, in the "Progressive Age" for Sept. 1, 1903. The following details as to the price of gas have been taken from the latter source:

The selling prices of gas within the borough are 32 cts. and 28 cts., and for motive power purposes 24.3 cts. per 1,000 cu. ft., net. Consumers of gas by slot or prepayment meter are allowed 40 cu. ft. for 2 cts., which includes service meter, internal pipes and fittings, with boiling burner, also the continual maintenance of same. The illuminating power of the gas is maintained at 18 candles, notwithstanding the fact that the statutory standard is but 14, as it is, in the opinion of the writer, much to the advantage of the consumer to supply gas of what may be termed an economical quality. In other words, had the present low selling prices been obtained by reducing the quality, the consumer could not be said to have been the gainer. The prices charged are lower than those of any other gas authority in the world. With regard to the price of 24.3 cts. per 1,000 for motive power purposes, it is interesting to note that this gas, which has a calorific value of 670 B. T. U., is 25% cheaper than Mond power gas at 6 cts. per 1,000. Widnes gas at 24.3 cts. per 1,000 develops 5.5 B. HP. in a modern gas engine for 2 cts., or, say, 0.36-ct. per B. HP., a price considerably below that of a high-duty steam engine, especially when costs of steam generating are included. Electricity for power purposes, to be comparable with gas at the Widnes price, must be sold at 0.5-ct. per unit. The gas undertaking contributes to the relief of the general district rate of the borough by doing the whole of the public lighting free of cost; which amounts to a charge of almost 4 cts. per 1,000 cu. ft. on the gas sold.

AN UNUSUAL ASPHALT BLOCK PAVEMENT which was laid in the city of Magdeburg, Germany, two years ago, is reported to be quite successful. The foundation course of the pavement consists of concrete blocks about 10 ins. square and 6 to 7 ins. thick. These are laid directly on the subgrade, the joints being filled with sand. The surface of this concrete-block foundation was covered with a very thin layer of fine sand, and then with ¾-in. of mortar, to serve as bedding for the surface or wearing course. This surface course consists of ready-made asphalt blocks, also about 10 ins. square, but only 2⅜ ins. thick; the lower ¾-in. of these blocks is made of cement mortar, the upper 1⅝ ins. of asphalt mastic. The blocks are bedded in the layer of mortar on the foundation, and the vertical joints filled with neat cement mortar. The cost of furnishing and laying this pavement (exclusive of cost of preparing the subgrade) was about 12 m. per. square meter, or about $2.50 per sq. yd. This pavement was laid in a narrow business street (only 8 to 14 ft. wide) where the vehicle traffic is exclusively local. It has been in use now for two years, and shows up very well, according to a note by Mr. Beer, the engineer for the work, in the "Centralblatt der Bauverwaltung." The concrete-block foundation was adopted, originally, for the reason that laying an ordinary concrete base would interrupt traffic too long. It has been found that opening the street for access to pipes is very easily done with this block pavement, and the repaired spots are hardly distinguishable from the original pavement. Most of the paving removed for such purposes can be used again in the repaving. A similar foundation has been tried under an asphalt surface of the ordinary continuous construction. While this has shown up well for the past year, the surface of the asphalt in some places shows markings corresponding to the blocks of the foundation, due to slight unequal settling of the latter. Mr. Beer suggests that wherever a continuous asphalt paving is to be used, the foundation concrete should also be continuous. The city of Magdeburg plans to extend the paving with asphalt blocks on concrete blocks to other narrow streets.

THE PRODUCTION OF ASPHALTUM in the United States during the past eleven years is given in a bulletin recently issued by the U. S. Geological Survey. It is interesting to note the increase in production that has taken place during the last 20 years, and especially the sudden jump occurring between the years 1901 and 1902. The quantity and value of the asphaltum and bituminous rock produced from 1882 to 1902, inclusive, was as follows:

Year.	Short tons.	Value.	Year.	Short tons.	Value.
1882...	3,000	$10,500	1893...	47,779	$372,232
1883...	3,000	10,500	1894...	60,570	353,400
1884...	3,000	10,500	1895...	68,163	348,281
1885...	3,000	10,500	1896...	80,503	577,563
1886...	3,500	14,000	1897...	75,945	664,632
1887...	4,000	16,000	1898...	76,337	675,649
1888...	50,450	187,500	1899...	75,085	553,904
1889...	51,735	171,537	1900...	54,389	415,958
1890...	40,841	190,416	1901...	63,134	555,335
1891...	45,054	242,264	1902...	99,659	677,594
1892...	87,680	445,375			

In the year 1902 a very large proportion of bituminous sandstone was produced, having a relatively less value per ton. The crude asphaltum imported for immediate consumption into the United States from 1867 to 1902, inclusive, was as follows for the year ending:

June 30,	Long tons.	Value.	Dec. 31,	Long tons.	Value.
1867...	.....	$6,268	1886...	32,505	$108,528
1868...	185	5,632	1887...	30,808	95,735
1869...	203	10,559	1888...	36,494	84,045
1870...	488	13,072	1889...	61,952	138,163
1871...	1,301	14,760	1890...	73,861	223,368
1972...	1,474	35,533	1891...	102,433	299,350
1873...	2,314	38,298	1892...	120,255	336,868
1874...	1,183	17,710	1893...	74,774	196,314
1875...	1,171	26,006	1894...	102,505	313,680
1876...	807	23,818	1895...	79,557	210,556
1877...	4,532	36,550	1896...	96,192	304,596
1878...	5,476	35,932	1897...	115,528	392,770
1879...	8,084	39,635	1898...	69,857	203,385
1880...	11,830	87,889	1899...	106,474	425,263
1881...	12,883	95,410	1900...	118,771	454,732
1882...	15,015	102,698	1901...	138,833	553,473
1883...	33,116	149,999	1902...	153,093	492,604
1884...	36,078	145,571			
1885...	18,407	88,087			

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear-end collision on the Erie R. R., near Turners, N. Y., on Aug. 29. One person was killed and 17 were injured. The collision occurred between the first and second section of a milk train. The cause of the collision is stated to have been due to an error of the signalman.

A SMALL DAM NEAR BUTLER, PA., failed on Aug. 28, working some injury to railway culverts below it.

THE SIX-MASTED STEEL SCHOONER "William L. Douglas" was launched from the Fore River shipyard at Quincy, Mass., on Aug. 29. This is the first six-master to be build of steel in this country. The vessel is 399 ft. 6 ins. long over all, and 306 ft. on the water line, with 48 ft. beam, and 29 ft. 9 ins. depth. Her loaded draft, carrying 5,700 tons of freight, will be 24 ft., and her displacement, 7,700 tons. The schooner's bowsprit and lower masts are of steel, the topmasts, booms and gaffs being of wood; the trucks of the six masts will be 120 ft. above the deck. The sails number 25, with a total area of about 32,000 sq. ft. The standing rigging requires 15,000 ft. of Roebling's charcoal wire rope and 11,000 fathoms of Plymouth manila cordage are necessary for the running rigging and hawsers. The "Douglas" was designed by B. B. Croninshield, of Boston, who also designed the seven-master, the "Lawson," and drew the lines of the racing yacht "Independence." While intended for a cargo carrier, the new six-master is well modeled and is expected to make eight or nine knots under ordinary conditions. Cargo will be carried on the two lower decks and in the hold and two large water-tight trimming tanks are provided for water ballast or cargo. Steam winches are provided for hoisting sails and anchors, and the boiler will also furnish power for the steering gear and the electric lighting dynamo, and heat for the quarters of officers and men. The schooner was launched without masts. She drew 8 ft. of water as she left the ways and floated with perfect trim. The "Douglas" is to be added to the fleet of large sail-craft of the Coastwise Transportation Co., of which Capt. John G. Crowley, of Boston, is the organizer, and to which the seven-master steel schooner "Thomas W. Lawson," launched at Fore River a year ago, belongs. She will be commanded by Captain Murdock McLeane.

THE NICARAGUA CANAL ROUTE is again being considered by the State Department at Washington, according to a special dispatch to the "New York Times" of Sept. 1. The failure of the Colombian Senate to ratify the Hay-Herran treaty is regarded by the Department as likely to result in such delays that the "reasonable time" set by Congress for the securing of right of way from Colombia may be considered to be exhausted. It will be remembered that the act providing for the purchase of the Panama concession for $40,000,000, also provided that in case the necessary concessions were not obtained from Colombia in a reasonable time, and on reasonable terms, the construction of a canal on the Nicaragua route should be undertaken. The protocols concluded by the United States with Nicaragua and Costa Rica in December, 1900, are still in force, and it is likely that the complete concessions necessary from these countries could be obtained with little delay.

RELIABILITY TRIALS OF MOTOR CARS will be held by the Automobile Club of England on Sept. 18 to 26, inclusive. Over 130 vehicles have been entered for the contest, about one-half of which are by English makers. Altogether the vehicles will be required to cover a distance of 1,019 miles in eight days, beginning and finishing each day's trip at the Crystal Palace, London. In rating the vehicles it is the intention of the club to give particular attention to absence of noise, vibration, dust raising, vapor and smoke; greater attention than in past trials will also be paid to the finish and appearance of motor and driving mechanism, and special effort will be made to get figures of fuel consumption extending over the whole working period of the trials. One peculiar feature of the rating is that 250 marks will be given to the vehicle which by actual performance gives a horse power equal or most nearly equal to the horse power at which it is described in the entry form.

NEW BLAST FURNACES with an annual capacity of 4,447,000 tons were under construction on June 30, 1903, according to information collected and published by the American Iron and Steel Association. Of the 32 furnaces being built two will use anthracite coal and coke mixed and 30 will use coke. The report says:

Summarizing the details given, it is found that of the 32 furnaces which were being built on June 30, 1903, 17 stacks, with a total annual capacity of 1,917,000 tons, are to be blown in during 1903, and 15 stacks, with an annual capacity of 2,425,000 tons, are to be blown in during 1904 or very early in 1905. Of the three old furnaces which were to be revived on June 30, 1903, one furnace resumed blast early in July and the remaining furnaces are to blow in very shortly. The annual capacity of these three furnaces amounts to 55,000 tons. The partly erected stack, which will not be completed until 1904, will have an annual capacity of 50,000 tons. Adding the capacity of the building furnaces to the capacity of the partly erected and rivived furnaces it is found that by the close of 1903 the productive capacity of the completed furnaces in the country will be increased to the extent of 1,972,000 tons, and that by the close of 1904 it will be further increased by 2,475,000 tons, or a total increase in the next 18 months of 4,447,000 tons, divided as follows: Coke, 4,247,000 tons; anthracite coal and coke mixed, 172,000 tons; and charcoal, 28,000 tons. Allowing for all the additions above noted, we estimate the annual capacity of the completed blast furnaces of the country on June 30, 1903, at 26,000,000 gross tons. If to these figures be added the annual capacity of the furnaces under construction on June 30 and of the old furnaces which were to be revived on that date a grand total of over 31,000,000 tons is reached as the approximate total yearly pig iron producing capacity of the country on December 31, 1904, when practically all the furnaces under construction on June 30, 1903, are to be ready for blast.

THE METROPOLITAN UNDERGROUND RAILWAY OF PARIS.

Construction of the North Circle.

The second section or line of the new electric underground railway of Paris, France, was recently completed and opened for traffic. This line is known as Line No. 2, or the "North Circle," and is 12,415 m. (7.7 miles) long. It extends from the Porte Dauphine to the Place de la Nation, and, with the South Circle, now in process of construction, will form a belt line which is substantially parallel to the old city wall and which will intersect all the principal boulevards radiating from the center of the city. The first line or Line No. 1, which was opened for traffic in 1900, intersects this circle diametrically in a general east and west direction. It should be stated in this connection that, besides Line No. 1 proper, there were opened for traffic in 1900 the portion of the North Circle from Porte Dauphine to Place de l'Etoile, and the portion of the South Circle from Place de l'Etoile to Place du Trocadero. The construction of these portions of the North and South circles in advance of the remaining portions of those lines was to give transit facilities to the Paris Exposition of 1900. The complete system calls for several other intersecting lines, but as these have not been commenced they will not be considered further. Altogether the lines completed, under construction, and projected aggregate 48¼ miles of road, the most of which will be underground structure, but much of which will be viaduct and open cut. The first intersecting line was fully described in Engineering News of Dec. 6, 1900. It extends from the Porte de Vincennes to the Porte Maillot, and is 8.7 miles long, so that the total length of road now open for traffic is 16.4 miles. Its location is shown by the map, Fig. 1.

The line from Porte Vincennes to Porte Maillot was entirely underground construction, but some 2,072 m. (6,796 ft.) of the North Circle are viaduct. It is this viaduct section that calls chiefly for description in the present connection, since the underground portions of the North Circle are substantially the same in design and construction as the older line completed in 1900. As will be seen by reference to Fig. 1, the viaduct section of the North Circle is situated about midway between the two terminals. In the lay-out of the line it is, moreover, only the terminals that call for particular mention. The general requirements of the location were: that no curve of less than 75 m. (246 ft.) radius should be used, except at terminals, and that effort should be made to secure curves with radii of at least 100 m. (328 ft.); that at least 50 m. (164 ft.) of straight line should separate adjacent curves in opposite directions; that no grade should exceed 4%, and that a vertical curve at least 50 m. (164 ft.) long should connect two grades forming a valley.

Turning now to the terminal lay-outs, we need only to state that the terminal at the Porte Dauphine is a simple loop formed by two straight lines intersecting at an acute angle and having their open ends connected by a circular curve of 30 m. (98.4 ft.) radius and embracing 215° 48′ of arc. The terminals at the Porte de Vincennes and the adjacent Place de la Nation are shown by Figs. 2 and 3. The arrangement of the connecting lines and underground structures is clearly illustrated by these plans. Referring to Fig. 2, it should be noted that the loop proper and the direct line connecting with it are portions of the line opened in 1900 and that the lateral connections alone belong to the construction of the North Circle. The connection of line No. 1, the North Circle and the South Circle at the Place de la Nation, should be observed in examining Fig. 3.

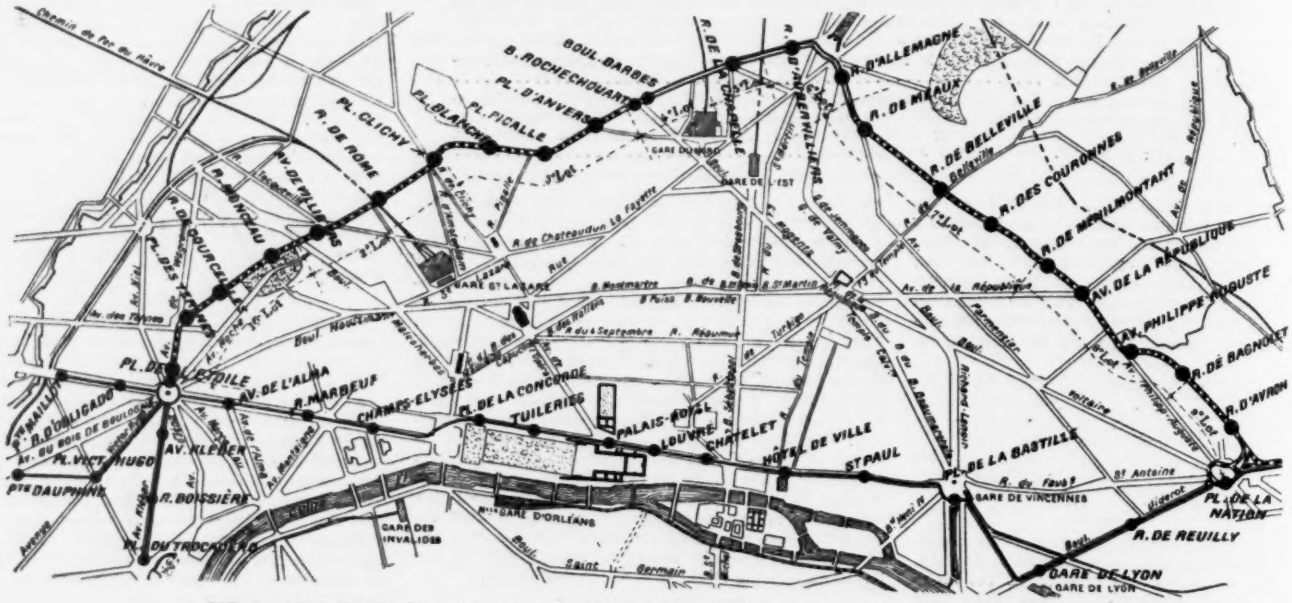


FIG. 1. MAP SHOWING COMPLETED LINES OF METROPOLITAN RAILWAY OF PARIS.

UNDERGROUND CONSTRUCTION.—The underground portions of the line forming the North Circle call for brief mention only, since both the structure and the method of construction were practically the same as for Line No. 1, which was described in Engineering News of Dec. 6, 1900. At a few places considerable difficulty was had with unstable material and special provisions had to be made to ensure a solid foundation. It is to be noted, also, that no use was made of the shield process of tunneling, all tunnel being driven by one or another of the familiar soft-ground timbering methods. Tunneling by means of roof shields was quite extensively adopted at the beginning of work on Line No. 1, but the slow progress made and other difficulties led soon to the abandoning of shields for soft-ground timbering methods of one kind or another. In the building of the North Circle no attempt was made to employ shields.

VIADUCT STRUCTURE.—The portion of the North Circle which consists of viaduct is 2,072 m. (6,796 ft.) long and is located between the boulevards Rochechouart and Villete, about midway of the line, as shown by Fig. 1. There is between the two boulevards named a slight surface depression, but it is so slight that the connections between the ends of the viaduct and the adjacent underground sections are accomplished by steep grades. On the face of things there would seem to have been no good reason for introducing this viaduct section, and as a matter of fact the action has aroused considerable criticism in the French technical press. As nearly as they can be got at matters appear to stand about as follows: This portion of the line crosses the railway lines and the Canal St. Martin, and some difficulty was anticipated in carrying the underground structure beneath these works. This seems to have been the only engineering reason for adopting a viaduct. Another reason of a different nature arose out of the long controversy between the advocates of a viaduct construction on one hand and the advocates of an underground construction on the other, which preceded the original planning of the system and which resulted in a sort of compromise in the nature of a part viaduct and part underground line structure. Against the wisdom of this compromise the following reasons are cited: The underground crossing of the two railway lines and the Canal St. Martin involved engineering difficulties no greater than have been successfully met at other points of the work; the cost of the viaduct has been nearly twice as great as an equal length of underground line; and, finally, the viaduct is unsightly and has rendered the property along its length less desirable to tenants.

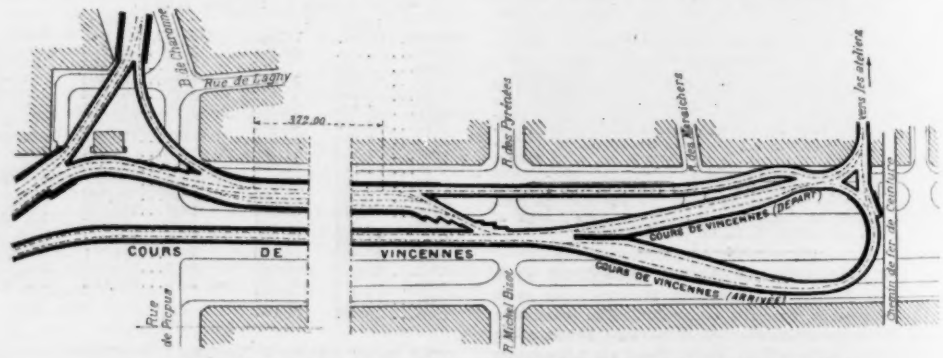


FIG. 2. PORTE DE VINCENNES TERMINAL OF METROPOLITAN RAILWAY.

Structurally the viaduct consists of a series of truss spans carried by cast-iron columns and masonry pillars. For the general run of viaduct the column supports are employed, but at stations and where heavy foundations are required, stone masonry pillars are substituted for the cast columns. The mean span length of the viaduct is 22 m. (72.2 ft.), but the spans vary greatly in

length, those crossing the railway lines being 75.25 m. (246.8 ft.) and those at the stations being 15 m. (49.2 ft.). Except at stations where a special construction is employed, the construction is the same for all lengths of span. It consists, for each span, of two parallel trusses fixed at one end and movable at the other end. A typical span is shown by Fig. 1. This is a 36.56-m. (119.8-ft.) span carrying the road over a cross street, and the center panel is counter-braced. In the shorter spans employed for the general use of viaduct no counterbalancing is employed, and in the three longer spans of 75.25 m. (246.8 ft.) the three center panels are counter-braced. These longest spans have a transverse bracing between the top chords of trusses, but the shorter spans are embraced in this respect. The panel lengths vary of course with the length of span, they being 4.25 m. (13.94 ft.) for the 75.25-m. spans and 1.5 m. (4.92 ft.) for the short spans for general viaduct.

The floor construction, for all spans but the longest, consists of transverse floor beams between panel points which carry brick arches plastered with mortar and filled above with ballast. This construction is clearly shown by Fig. 5, which also shows the means for draining the ballast filling and the method of supporting the trusses on the columns. In the 75.25-m. spans the floor system consists of transverse girders at panel points connected by a line of stringers under each track rail. On this floor frame is placed a sheeting of corrugated iron to catch the rain water. A timber longitudinal on each stringer carries the track rails. The transverse section, Fig. 6, of one of the spans shows quite clearly the construction described.

The nature of the east column supports for the viaduct is quite clearly indicated by Fig. 5. The columns are tapering and fluted, with ornamental capitals, but with their bases sunk beneath the pavement, and resting on suitable pedestal foundations of masonry. A fine idea of the masonry pillar supports at street crossings and other special locations may be had from Fig. 4, showing the crossing at Rue de la Chapelle, and Fig. 7, showing the double span crossing of the Chemin de Fer du Nord. Some of the foundations of these pillars involved considerable difficulty in construction, as will be noted further on.

The drainage of the viaduct structure has already been referred to, but it calls for some further mention. Referring to Fig. 5, it will be seen that the brick floor arches are dished transversely of the span so as to drain the water to the pipes, T. These pipes discharge into a trough, C, which runs the whole length of the viaduct and is provided with suitable low points at supports at suitable intervals. At these low points the longitudinal trough drains into a transverse trough, K L, which leads to the down spouts, M, at columns. The special hangers for supporting the troughs are clearly shown by Fig. 5, which also shows the expansion joint connection between the floor systems of adjacent spans.

Before closing reference to the viaduct structure it should be remarked that its clear height above the street is everywhere 6.5 m. (21.32 ft.), and that its grades conform closely to the street grades. This is said by our French contemporaries to give the structure, when viewed as a whole, a rolling profile which detracts much from its appearance.

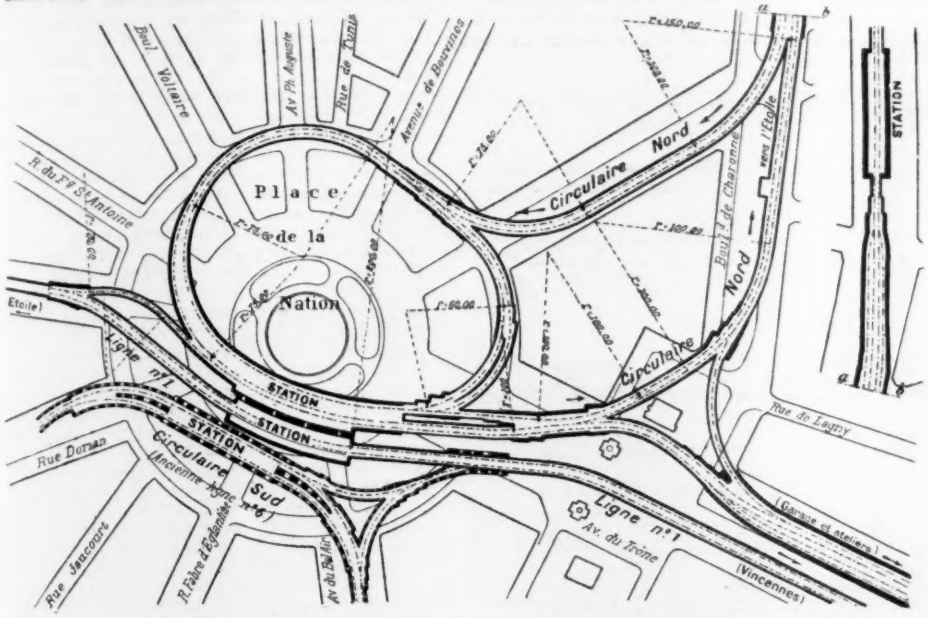


FIG. 3. PLAN OF UNDERGROUND LINES AND STATIONS AT THE PLACE DE LA NATION.

STATION CONSTRUCTION.—Including the three stations constructed in 1900 at Porte Dauphine, Place Victor Hugo and Place de la Nation, in connection with Line No. 1, there are 25 stations on the North Circle line. Four of these stations are on viaduct and the others are underground. The underground stations are practically the same in design and construction as those of Line No. 1, which were described in our issue of Dec. 6, 1900, and they will not be considered further. The viaduct stations are constructed as shown by Fig. 8. Each station is carried by five spans of 15 m. (49.2 ft.), each consisting of four lines of girders. The interior girders are plate girders and the outside girders have a braced web closely resembling that of the viaduct girders proper. The top chord of the outside girders is horizontal and the bottom chord is slightly arched. The outside girders carry the columns which support a cantilever shed roof which overhangs each platform. The platform floor construction and the track construction is clearly shown by Fig. 8, which also show the other principal structural details. Access and exit are obtained by means of stairways at one end of the station. It should be mentioned that the masonry pillars at the ends of the station structure are carried up to the level of the shed roof and resemble the abutment pillars of the 75.25-m. spans, as shown by Fig. 7.

VIADUCT CONSTRUCTION.—The construction of the viaduct involved two classes of work, namely the foundation construction and the erection of the superstructure, and each possessed features of interest. The subsoil of the streets traversed by the viaduct was of a very unstable nature until a considerable depth was reached. Two types of foundations were employed. Where the soil was most favorable clusters of piles were driven to a firm bracing and capped with a mass of concrete. At more unfavorable localities pits were sunk through the overlying unstable material and shafts of concrete were erected therein on which were set the east columns or stone pillars. In several instances special constructions were necessary. An example of these is shown by Fig. 9.

The erection of the viaduct structure was done by two different contractors, each of which adopted a different mode of procedure. The portion from the Boulevard Rouchechonart to the Chemin de Fer du Nord was erected by the La Société des Atiliers de Montreuil. It was composed of spans varying from 22.5 m. to 35 m. The procedure followed was to ship the trusses in as large sections as possible, and to erect these sections by means of gantry cranes which straddled the viaduct and ran on tracks on the street surface. The 35-m. span was erected by means of falseworks. The method of erecting the section from the Chemin de Fer du Nord to the Rue de Meaux was to construct a section of falsework of several spans in length and to erect all the metalwork from it in small sections. This falsework was so designed that the rear bays could be taken down and carried forward, thus continually advancing the structure. This method of erection is shown diagrammatically by the elevations and sections of Fig. 10. Mounted on the forward end of the falsework there was a gantry crane, A, for erecting the columns. This was followed by a similar crane, B, for erecting the viaduct spans in small sections. Following the second crane were three riveting sheds, each of which was provided with a centrifugal pump operated by an electric motor and pumping to an accumulator, with a bridge crane carrying the hydraulic riveting machines and with a rivet-heating furnace and other necessary accessories for riveting work. The contractors for the erection of this portion of the line were Moisant, Laurent, Savey & Co., of Paris, France.

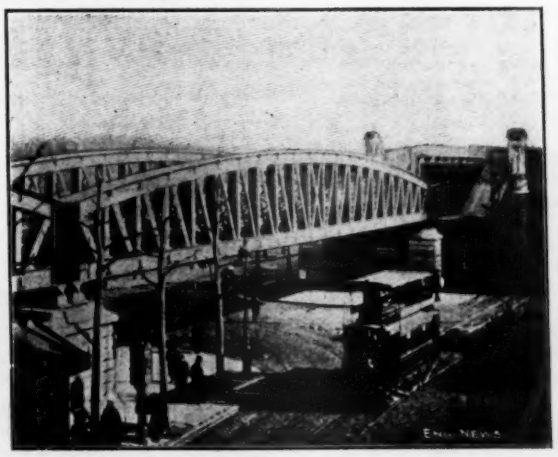


Fig. 4. View of Viaduct Crossing the Rue de la Chapelle.

Fig. 13. General View of Viaduct Structure.

TRACK CONSTRUCTION.—Several of the illustrations previously mentioned show the general character of the track construction. Except on the longer spans of the viaduct structure it consists of track rails and conductor rails of the Vignoles type, carried on cross ties laid in ballast. Fig. 11 is a transverse section of one of the track rails at a joint. Two lengths of rail are employed. For tangent and curves of less than 150 m. (492 ft.) radius the rails are 18 m. (59 ft.) long, and for curves of less than 150 m. radius they are 9 m.

(29.5 ft.) long. The long rails have 20 ties and the short rails have 12 ties. The ties are normally 0.2 × 0.14 × 2.5 m. (7.88 × 5.52 ins. × 7.2 ft.), but every fourth tie is made 2.5 m. (8.2 ft.) long to carry the outside conductor rail. The track rails weigh 52 kgs. per lin. m. (104.4 lbs. per yd.); their principal sectional dimensions are shown by Fig. 11. The joints are suspended and are composed of six-bolt angle bars 0.8-m. (2.62 ft.) long. The ties for the underground track are of oak, and those for the viaduct track are creosoted beech.

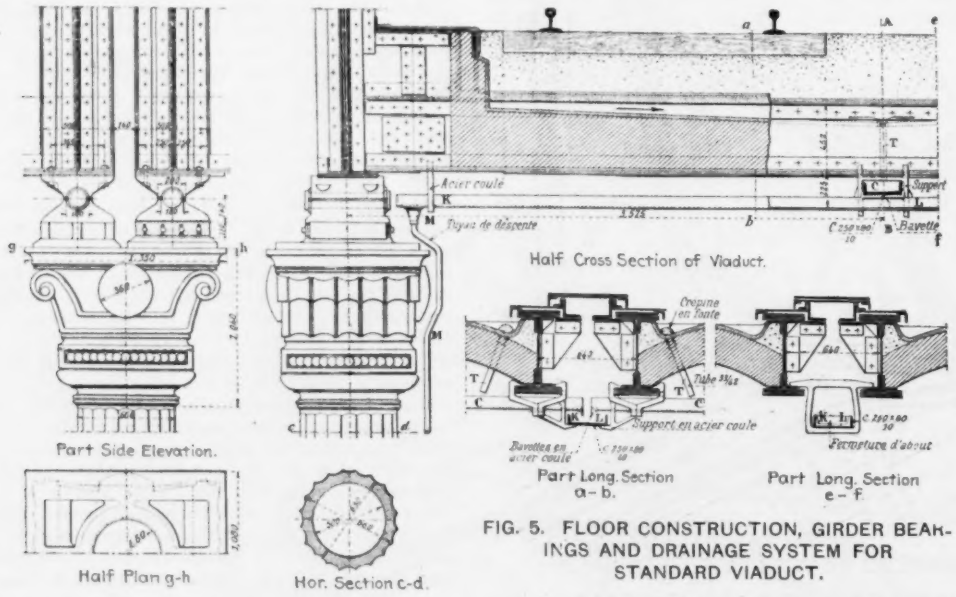


FIG. 5. FLOOR CONSTRUCTION, GIRDER BEARINGS AND DRAINAGE SYSTEM FOR STANDARD VIADUCT.

A sluice of poplar is inserted between the rail base and each tie. The ballast is stone, and is filled flush with the tops of the ties and has a depth of 0.2-m. (7.8 ins.) beneath their bottoms.

The conductor rail is of the same section as the track rail, but is rolled from softer steel. It is carried on every fourth tie, or at intervals of 3.28 m. (10.66 ft.), by means of the insulated supports shown in section and plan by Fig. 12. The support consists of a cup-shaped base or socket casting which is bolted to the tie, and of a pivot casting which is separated from the socket by an insulating material, and in which the rail is clamped. The rail joints are four-bolt angle bars. The electric connections are made by copper wires.

COST OF CONSTRUCTION.—The cost of the North Circle line varied from 1,227 frs. to 1,670 frs. per meter for underground line, and ran as high as 2,560 frs., 2,895 frs. and 3,549 frs. per meter for viaduct. It was 29,629,200 frs., or 2,811 frs. per meter for the whole line. The cost of Line No. 1 was 2,646 frs. per meter. The excess in cost of the North Circle line over Line No. 1, was due to the greater cost of the viaduct line.

The line was built under the direction of M. Bienvenue, Chief Engineer, and M. Biette, Assistant Chief Engineer. We are indebted to "Le Genie Civil" of March 28, 1903, and to the "Revue Générale des Chemins de Fur" for April, 1903, for the facts from which this description of the work has been prepared.

DIFFERENCES OF OPINION AS TO LINING THE TROY WATER-WORKS TUNNEL.

A controvery has arisen over the necessity of lining a tunnel forming a part of the water-works improvements now being carried out for the city of Troy, N. Y. As this controversy has led to the resignation of the chief engineer for the work, Prof. Wm. G. Raymond, M. Am. Soc. C. E, of the Rensselear Polytechnic Institute, and particularly as it raises some interesting points in both engineering construction and engineering ethics the greater portion of reports by three consulting engineers engaged by the Municipal Improvement Commission, and a condensation of Professor Raymond's subsequent letter of resignation, are here published. For the sake of clearness, it may be stated that the main points at issue are: (1) Whether the Hudson River shale pierced by the tunnel is a soft and seamy rock, entitling the contractor to demand that the tunnel be lined with concrete? (2) Under the specifications, who was to settle this point? In addition, it may be asked, was it justifiable for the members of the improvement commission to call in outside engineers to aid them in settling (1) and (2) without consulting their chief engineer, and without giving him any opportunity to confer with the engineers, and to present formally his side of the case before being ordered to have the tunnel lined? On the last two points we propose to let the several reports speak for themselves. Much the same course has been followed as to the character of the rock in question and the necessity of lining this particular tunnel, but elsewhere in this issue there may be found a general discussion of lining water-works tunnels driven through shaley rock.

Of the four reports under consideration, the first two were addressed to Mr. Henry Schneider, President Municipal Improvement Commission, Troy, N. Y., and the last two were addressed to the Commission. The reports are of various dates

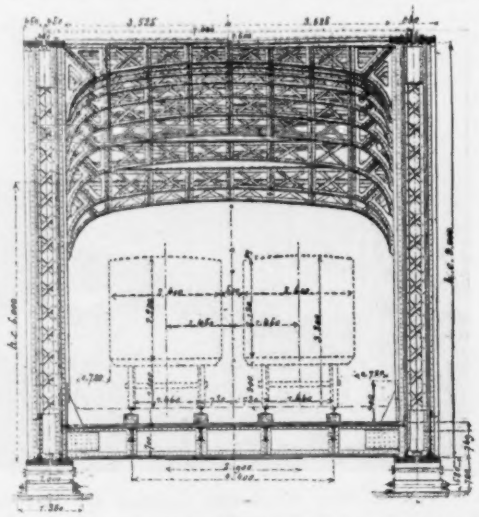


Fig. 6. Transverse Sectional Elevation of 75.25-m. Span at Center.

within the past two months or so, and Professor Raymond's letter to the commission was dated Aug. 12. The report and letter follow:

REPORT BY MARTIN SCHENCK* (SLIGHTLY CONDENSED).

I recently examined the completed portions of the tunnel in process of construction by Contractor Harrison, on the line of water-works being built for the purpose of conducting water to the city of Troy from Tomhannock Creek. . . . The rock in all portions of the tunnel examined by me, is Hudson River shale of the usual character. . . . I found places where the character of the rock, in portions of the tunnel already excavated, was such as would seem to warrant the use of lining of some kind; and in the portions yet to be excavated conditions may arise that will require still further use of lining, in order to insure safety.

There are also indications of soft rock in portions of the tunnel, that would indicate that there may be danger of disintegration to an extent that would endanger the safe working of the tunnel.

As a matter of fact, some of the excavated rock does disintegrate when exposed to the air and subjected to alternate moisture and drying out; but experience goes to show that there is not much danger of serious disintegration of the Hudson River shales, under water or where not disturbed or broken up. But it would be somewhat hazardous to say that there would be no disintegration in this tunnel that might cause serious results.

From what I could gather in conversation with Contractor Harrison, I surmised that he was willing to do the lining at the price stipulated in the specifications—$7 per cu. yd.—but I very much doubt that he could make a safe or satisfactory job with concrete; and it is difficult to see where he could possibly be benefited by using concrete, as the price fixed is not a princely one for that kind of work in a small tunnel—in fact, not greater than we pay here for concrete in bridge piers and abutments. However, that is a matter which concerns the contractor, and is foreign to the question at issue, which is: "Is the rock through which this tunnel has been cut of such a nature as would warrant the use of lining?" In my opinion, backed by a reasonable amount of experience, the use of concrete lining would not insure safety, nor warrant the expense necessary to be incurred, as it would be next to impossible to make a safe and satisfactory job with concrete, and it would be quite as safe to take chances on the tunnel in its present condition.

In conclusion, permit me to say that it is self-evident that the lining of this tunnel for its entire length would produce a more finished, much safer and more satisfactory job; at the same time, I do not believe that concrete is the proper material for remedy in the case, and I would advise that, instead of concrete, iron pipe of suitable dimensions be laid throughout its entire length, as the cost would be no greater, and the results far more satisfactory, and would insure proper and safe working of the tunnel for all time.

REPORT BY CARROLL P. BASSETT,† M. AM. SOC. C. E. (CONDENSED).

To the specific question submitted "Is the rock encountered in the tunnel soft seamy rock within the meaning of the specifications?" I have replied that "I cannot avoid the conclusion that the rock is a soft, seamy rock interpreted as a rock classification." The grounds for this conclusion may be outlined as follows: There is no mention in the specifications under which the contract is being conducted of the character of the rock to be encountered. It is not stated to be shale, or granite, stratified or igneous. Nor do I consider that a contractor in entering into this contract should be assumed to have legal knowledge that the rock to be encountered was shale. The only specification in the contract covering the matter is as follows:

> The approach and tunnel shall be excavated to the grade, lines and forms furnished by the commissioner of public works, and in general as shown on plans now on file in the office of the commissioner of public works. It is expected that the tunnel will be in self-supporting rock. If so it will be excavated so that no point of rock projects inside the neat lines. Where the material is soft, seamy rock or earth the tunnel will be excavated to larger dimensions than shown on standard sections and to a section to be determined by the commissioner of public works, and shall be lined.
>
> * * * * * * * * * * *

It seems to me clear, under all the circumstances, that, considering the contract as a whole, much, if not all, of the rock encountered is soft seamy rock. A large amount of it I should call hard, seamy shale, but Hudson River shale is not classed as hard rock; hence the conclusion that under rock classification in the abstract it would fill the specification of soft, seamy rock.

There is another view of this matter which should not be overlooked. You are constructing an elaborate system for a gravity water supply upon which a considerable portion of the city will be dependent. The dam and embankment, the spillway and overflow channel are substantially and expensively constructed to secure the utmost permanence. It would seem to be unwise to take any risk of permanence in this outlet tunnel. No reports can be made to it in the future without the greatest public inconvenience. . . .

REPORT BY EDMUND GYBBON SPILSBURY,† M. AM. SOC. C. E., M. AM. INST. MIN. E. (SLIGHTLY CONDENSED.)

. . . I find that the tunnel is driven entirely through what is known as the Hudson River shale, and the generic name itself of these rocks would designate them both as soft and seamy. It is probable, however, that the expression used in the detail specifications contemplated a still softer rock than has been found here, but at the same time, after the careful examination I have made, I feel

*Ex-State Engineer of New York.

*Summit, N. J.
†45 Broadway, New York.

justified in recommending to you that the major part, if not the whole, of this tunnel should be lined as provided for. While there are certain portions of the tunnel in which the rock at the present time might be considered as self-supporting, I find on examination of the material which has been excavated and is now lying on the dumps, that a very short exposure to atmospheric influences has resulted in considerable deterioration and disintegration of the material. For the first two or three hundred feet in from the portal on the east end there is no question about the absolute necessity for lining the tunnel. Beyond the portion which the contractor himself has had to timber in order to prevent caving, the stratification changes quite materially, and in some places the rock becomes much harder, but at the same time I notice the appearance of a number of cross slips or heads which cause the rock, after it has been exposed for a short while to atmospheric influences, to loosen and drop out in blocks. In testing the roof of the tunnel through the whole length, I find there are but few places which are not more or less drummy, which shows that further falls of rock may be expected at any time; in fact, several such falls of pieces weighing several hundred pounds took place while I was testing the roof. In two places west of the No. 4 shaft I found heaps of material to the amount of several wheelbarrow loads which had fallen out from the roof since the work had been done. Between the No. 1 shaft and the No. 2 gate house the roof has in places fallen in so that the present height of the tunnel is over 15 ft., and I am informed that these falls are of almost daily occurrence.

From an experience of over 40 years in mining operations and from a thorough knowledge of the rapid disintegration which these rocks are subject to when exposed to atmospheric influences, I do not hesitate to say that this sloughing off and constant falling of the roof will continue in an increased ratio as time goes on, and I consider that it would be, to say the least of it, very poor economy to leave the tunnel in its present condition. If the tunnel were to be used in such a way that ready access to it could at all times be maintained, there might be some excuse for deferring the lining to some future day when it became absolutely necessary. Such, however, is not the case here, and when once the water is admitted no further inspection of the work will be possible and no warnings of what deterioration may be going on will be given until the flow of water itself is obstructed. It might be one or two years before anything of this kind happened, but in the long run it will unavoidably occur unless the tunnel is lined. If the cross-section of the tunnel had been larger and care had been taken to properly arch the roof a good deal of this danger might have been avoided, but even then I doubt whether it would have been prudent to omit the lining. Even now in putting in a lining it will be advisable to have the contractor carefully remove all the very loose material and fill the cavities so made with concrete, otherwise the disintegration will continue back of the concrete and cause local pressures which might result in the giving away of the lining. I would also advise that the contractor be not allowed to use any of the shale extracted from the tunnel in the composition of his concrete, as the material is utterly unfit and too soft to use for this purpose.

FIG. 7. VIEW OF VIADUCT CROSSING THE CHEMIN DE FER DU NORD.

EXTRACTS FROM PROFESSOR RAYMOND'S LETTER OF RESIGNATION.

I have received from you the following letter:

Professor W. G. Raymond, Consulting Engineer, Troy Water-Works Extension. Dear Sir: After careful consideration of the reports of three engineers whom we have had examine the tunnel now being constructed by Harrison & Sons Co., this commission has come to the conclusion and decision that the tunnel shall be lined with concrete as provided for in the specifications for said tunnel.

We suggest that, at your earliest convenience, you consult with P. H. Harrison and decide upon plans for cross-sections for said linings.

The letter suggests a consultation with the contractor—seemingly—nothing else being mentioned, as to the section to be adopted for the lining ordered.

The specifications provide that the commissioner of public works shall determine the section to be adopted, and it does not appear to be a part of the duty or privilege of the contractor to dictate or suggest in the matter.

Nevertheless, I have consulted with the contractor, and he informs me that he wishes to line the tunnel, only provided the plans adopted under the terms of the specifications conform to the demands heretofore made by the contractor, namely: That all material already excavated shall be paid for at the contract price for rock excavation in the tunnel; that further excavation necessitated by the order to line shall be paid for at an increased price per cubic yard or done under a force account agreement; and that all concrete necessary to fill the entire space excavated beyond the new lines prescribed shall be paid for at the contract price per cubic yard.

The adoption of such a plan by the commissioner of public works or your honorable board would in my opinion be grossly improper and would render the persons responsible for it liable to justly severe criticism. I certainly cannot advise it.

* * * * * * * * * * * *

I am sorry that you have come to a decision to line the whole tunnel without first asking for the views of those more or less familiar with the work and whose interests are identical with your own—namely, the interest of the city.

You have had three engineers examine the tunnel and report to you. I have seen their reports, but I have been denied the privilege of using them in the preparation of this statement.

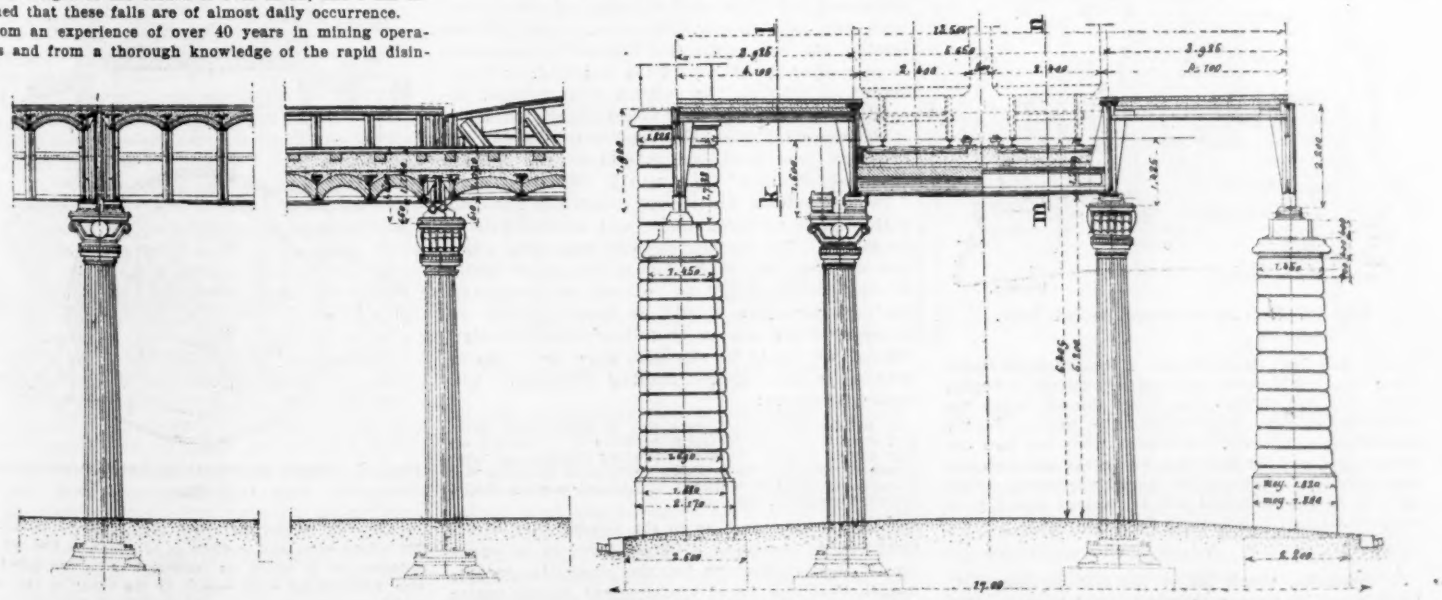
Moreover, you have not, prior to reaching your decision in the matter, asked me for any comment on these reports, nor for a formal expression of my views, nor have you sought comment or advice from engineers directly in charge of this work, engineers much more familiar with it than I or any of those who have reported to you, nor have I been present at any of your several conferences, nor informed or advised with concerning the employment of other engineers, but was refused the counsel of eminent engineers that I asked for.

* * * * * * * * * * * *

In severing my connection with this work I desire to make the following comment on the necessity for lining the Tomhannock tunnel, in order that you and my successor may be fully informed of the conditions, and in justice to myself.

* * * * * * * * * * * *

Permit me to call your attention to the fact that the



Long. Section k-l. Long. Section m-n. Transverse Section.

FIG. 8. GENERAL DETAILS OF STATION CONSTRUCTION ON VIADUCT.

tunnel, to date, throughout the major portions so far completed, is entirely self-supporting; that where it is not so it has ever been my purpose to have it protected; that Hudson River shale formation does not necessarily imply a soft rock, because this formation contains some of the hardest rocks known to geologists, and the samples taken from this tunnel, from the softest to the hardest, vary in hardness from the hardness of soft slate to the hardness of hard limestone; the major portion of the rock excavated being of about the hardness of limestone in its several different forms.

The foregoing determination of hardness were from actual tests made with standard minerals.

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As to the self-supporting character of the rock through which the tunnel is driven, I will refer you to a letter from Mr. Grimes, under date of Aug. 5. This letter gives

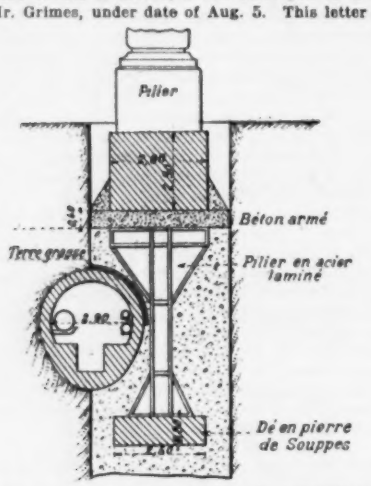


Fig. 9. Special Foundation Construction.

very positively Mr. Grimes' opinion as to whether the rock is soft and seamy, and as to whether it is self-supporting, and I know of no one more familiar with this tunnel than Mr. Grimes. In this connection I desire also to mention what was probably unknown to Mr. Spilsbury, and what in my own mind is better evidence as to the necessity for lining this tunnel than any number of years' experience with materials and conditions elsewhere, namely, that there exists in the upper end of Troy, through essentially the same rock, a tunnel approximating the Tomhannock tunnel in cross-section, which has been in constant use carrying water from the Hudson River to the Lansingburgh pumping station for about 30 years last past, and further that there exists in the hill district of this city, in connection with the power developement of the Marshall estate, a tunnel about 7 ft. in diameter, driven through shale and slate rock lying as badly as the worst of the Tomhannock tunnel, as soft and seamy as anything in the Tomhannock tunnel, and that this tunnel on the Marshall estate has been in use for about 60 years unlined and has never caved. It was thought when the

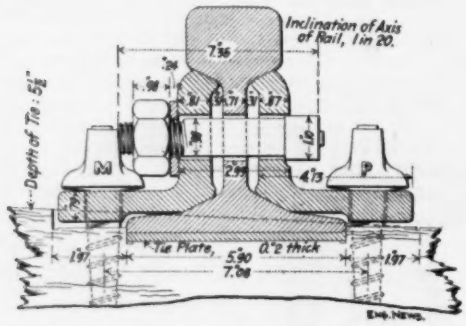


Fig. 11. Section of Track Rail at Joint.

tunnel was built that because it was through seamy shale rock that it would leak, and consequently a wooden trunk was laid through the tunnel through which the water used for power was brought to the wheels. For the past 30 years, however, this wooden trunk has been out of existence, and the bare rock tunnel has been carrying the water, and although this tunnel approaches within 10 or 15 ft. of a precipitous cliff, the leakage from it is so insignificant that it has never been considered.

* * * * * * * * * *

In conclusion, permit me to say that my judgment, based in part on my own observations and in part on the opinions of my assistants and Mr. Reudemann, and in part on the experience with similar tunnels in this vicinity, is that for a small portion of its length the Tomhannock tunnel should be protected; that for the major portion of its length it is entirely safe and everlasting; that it is worse than useless to line it with concrete or any other material.

Some rough estimates made of the cost of doing the work, deemed by your entire engineering force to be unnecessary, indicate that, if performed in accordance with the demands of the contractor, this work will involve the expenditure of not less than $65,000, and perhaps as much as $90,000.

As to the probable standing of the contractor in court, in case he should enforce his demands to line the tunnel, permit me to call your attention to the terms of the contract, which provide that the commissioner of public works, and not the contractor, shall interpret the specifications, and further that it lies within the power of the commissioner of public works to determine upon the amount of work to be done.

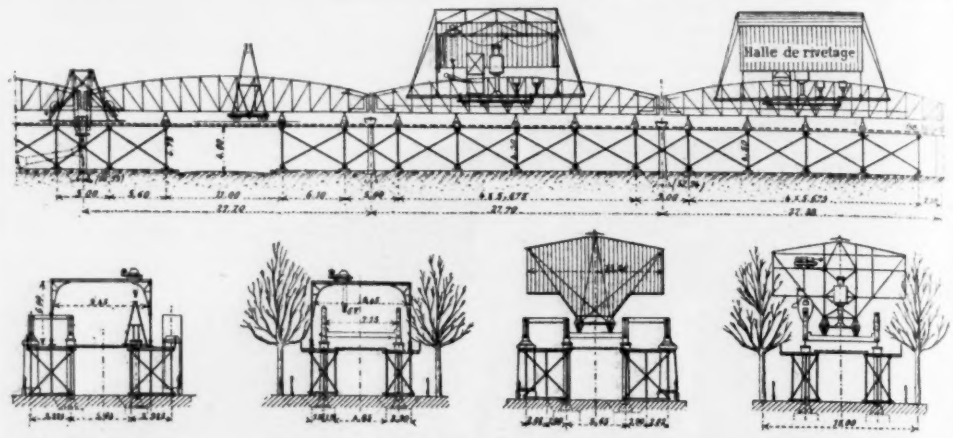


FIG. 10. SKETCH SHOWING METHOD OF ERECTING VIADUCT LINE.

Further than this, permit me to call your attention to the clause in Mr. Spilsbury's report which states that in his opinion by soft and seamy rock the detailed specifications contemplated a softer rock than was encountered in the Tomhannock tunnel.

This statement is exactly in accordance with the truth and confirms entirely the position that I have taken in the matter, and that I have expressed to you, individually, at various times, although not formally.

BRITISH REPORT ON MUNICIPAL TRADING AND MUNICIPAL ACCOUNTING.

In 1900, and again in 1903, a British joint parliamentary committee was appointed to investigate and report on municipal trading, or as we in America would say, municipal ownership. The report of 1900 was a "blue book" of 512 pages quarto, and consisted wholly of "minutes of evidence," prefaced by a half dozen lines recommending that the committee be reappointed during the next session. Another committee was not appointed until late in the session of the present year, and as such committees terminate with the session, the late committee deemed it impossible to pass upon the merits of the question, and concluded to take up the subject of municipal accounts, as closely related to municipal trading.

The report of the committee, not including the evidence, was published in full in the London "Contract Journal" for Aug. 12, 1903.

The committee considered municipal accounts with regard to form, audit and accessibility to taxpayers. The committee truly says that whatever opinions may be held as to the proper limits, if any, which should be placed on municipal trading, taxpayers should be kept as fully informed "of the success or failure of each undertaking" as would be the case were they "shareholders in an ordinary trading company." The report continues:

> In a large number of cases this is undoubtedly done. But there is in some instances evidence to a contrary effect, and in view of the ever-increasing number and magnitude of municipal undertakings, it is most desirable that a high and uniform standard of account-keeping should prevail throughout the country.

Doubt is expressed as to the advisability of attempting to prescribe a single form of accounts for all local authorities, but the committee recommends that the Local Government Board invite the various bodies of accountants "to confer and report on the matter."

A uniform system of audit is recommended for "all the major local authorities," that is, practically everything but rural districts. The present systems of auditing, which need not be described here, are believed to be highly unsatisfactory, and a more systematic, centralized and uniform system is recommended. The audit should "not be confined to mere certification of figures." It is further recommended that:

(a) The auditor should have the right of access to all such papers, books, accounts, vouchers, sanctions for loans, and so forth as are necessary for his examination and certificate: (b) he should be entitled to require from officers of the authority such information and explanation as may be necessary for the performance of his duties; (c) he should certify (1) that he has found the accounts in order, or otherwise, as the case may be; (2) that separate accounts of all trading undertakings have been kept, and that every charge which each ought to bear has been duly debited; (3) that in his opinion the accounts issued present a true and correct view of the transactions and results of trading (if any), for the period under investigation; (4) that due provision has been made out of revenue for the repayment of loans, that all items of receipts and expenditure and all known liabilities have been brought into account, and that the value of all assets has in all cases been fairly stated.

Auditors should be required to express an opinion upon the necessity of reserve funds, of amounts set aside to meet depreciation and obsolescence of plant in addition to the statutory sinking funds, and of the adequacy of such amounts.

The auditor should also be required to present a report

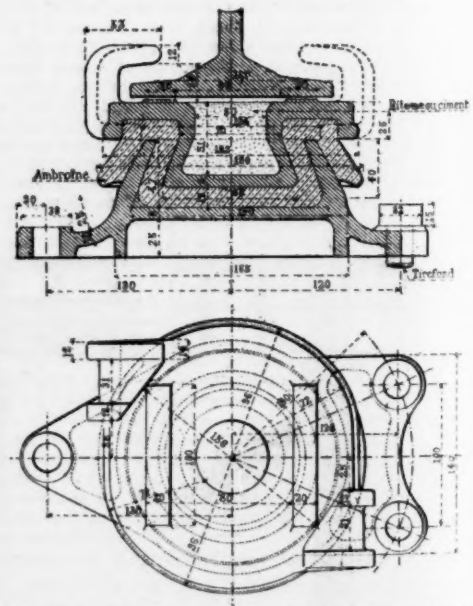


Fig. 12. Details of Insulating Support for Conductor Rail.

to the local authority. Such report should include observations upon any matters as to which he has not been satisfied, or in which his judgment called for special notice, particularly with regard to the value of any assets taken into account.

The local authority should forward to the Local Government Board both the detailed accounts and the report of the auditor made upon them. It should be the duty of the auditor to report independently to the Board any

case in which an authority declines to carry out any recommendation made by him.

A printed copy of the accounts, with the certificate and report of the auditor thereon, should be supplied by the local authority to any ratepayer at a reasonable charge.

A Board of Commissioners of Local Audit is suggested, and finally the committee advises that a future session of Parliament should continue "the investigation into other branches of the subject of municipal trading."

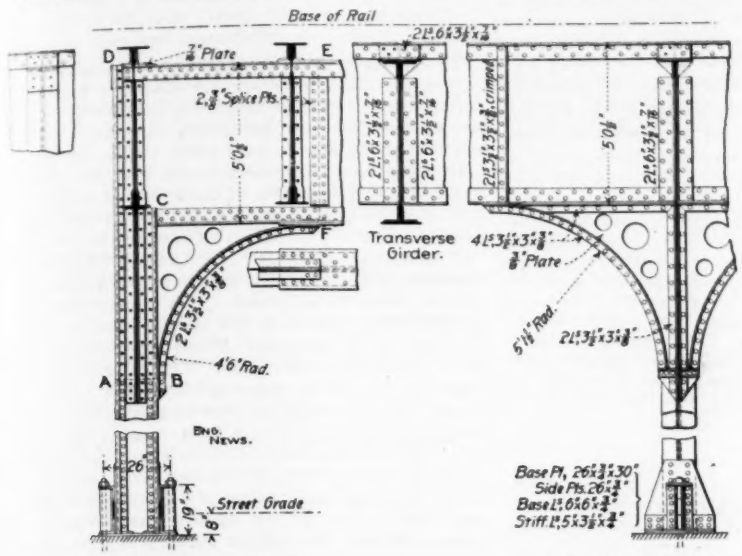


Fig. 134. Transverse Sectional Elevation.

Fig. 135. Longitudinal Sectional Elevation.

FIGS. 134 AND 135. DETAILS OF TWO-COLUMN BENT CONSTRUCTION, RAPID TRANSIT RAILWAY.

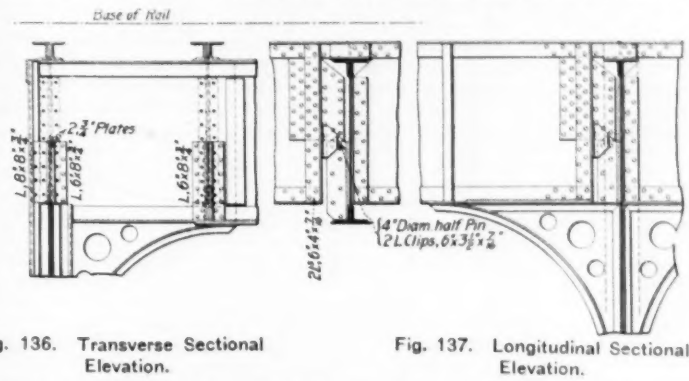


Fig. 136. Transverse Sectional Elevation.

Fig. 137. Longitudinal Sectional Elevation.

FIGS. 136 AND 137. DETAILS OF EXPANSION CONNECTIONS IN TWO-COLUMN BENT CONSTRUCTION.

THE NEW YORK RAPID TRANSIT RAILWAY.

XXII.

Elevated Structure.

Section X. of the East Side Line and Section XV. of the West Side Line are elevated three-track railway. These are the terminal sections of the Rapid Transit Railway on the north, and are 17,012 ft. long and 8,400 ft. long, respectively. The total length of elevated line, including the Manhattan Valley Viaduct, is, therefore, 5.22 miles The contractor for the steel work was the American Bridge Co.; for the erection, the Terry & Tench Construction Co., of New York city; and for the foundations, E. P. Roberts, of New York city.

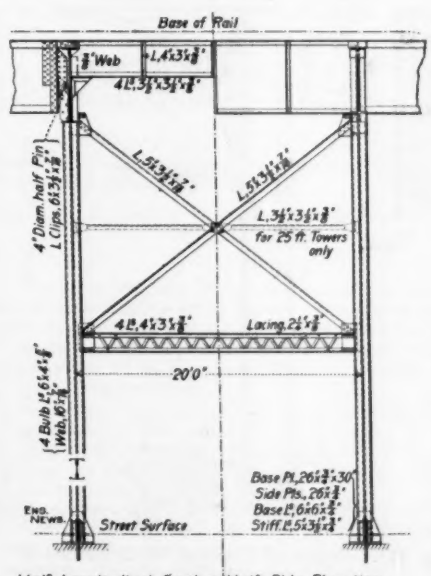
GENERAL DESCRIPTION. — The elevated structure of the Rapid Transit Railway is generally on tangent and very flat curves, which made it practicable to adopt a standard construction for the greater part of both lines. Where the height of the rail was not over 29 ft. above the street grade a two-column bent construction was adopted, the columns of each bent being 29 ft. apart and the bents themselves being spaced from 45 ft. to 65 ft. apart, but usually 50 ft. apart. Where the elevation of the rail was over 29 ft. above grade a double-bent tower construction was adopted, the towers being spaced from 70 ft. to 90 ft. apart between centers. The towers were 20 ft. and 25 ft. in width longitudinally, depending upon their height. The spans connecting the towers and bents were heavy plate girder construction. The bents and towers were set square on tangents and radially on curves. At the northern extremities of the sections where switch tracks were necessary the standard construction was modified by spacing the columns 50 ft. apart transversely, and at 174th St., on the East Side Line, a special curve construction was adopted for a short distance. In all cases the columns were of I-section composed of four bulb angles and a web plate, and the cross-girders and stringers were all plate girders. The only lattice girders used on the work were those employed at a few points for supporting station platforms.

FOUNDATIONS.—The foundations for the elevated structure consisted simply of granite-capped concrete pedestal footings for the bent and tower columns. These pedestals were square in plan with stepped pyramidal sides, and each contained two embedded anchor bolts. They were built in open pits carried down in each case to good foundation soil, and were capped at the level of 8 ins. below the grade of the street. On Sec. 15, where the elevated line crosses the salt marshes adjacent to the Harlem River, each foundation was carried on 9 piles, driven to an average depth of 42 ft., and cutoff at Elevation 0. The method of construction was simply to ram the concrete in boxlike forms of sizes suitable to mold the different steps, and then to set the granite cap on the concrete with a mortar joint. The anchor bolts were built into the concrete by means of templates and were grouted into the granite cap which was drilled to slip over them. The foundation pedestals were built at various periods extending over a couple of years.

STANDARD BENT CONSTRUCTION.—The standard bent construction for elevated structure is shown by the drawings of Figs. 134 to 137. It was employed for all portions of both lines where the rail level was not more than 29 ft. above the street grade. Each bent, as will be seen, consisted of two columns connected across the street by a transverse plate girder. The connection of the cross-girder to the columns is shown by Fig. 134. Referring first to the column it will be seen that the web was stopped at A B, the inside angles were continued up to C and the outside angles to D, the top of the cross-girder. The girder web was stopped at E F, but the chord angles were continued to C and D, respectively. This construction left space to insert the solid web knee, brace A B F E D. This knee brace was, of course, riveted up at the mill and in one piece with the cross-girder, the field riveting being confined to its connection with the column angles. The splice between the column web and the web of the knee brace at A B was made by the longitudinal knee braces for the outside track stringers, shown in Fig. 135.

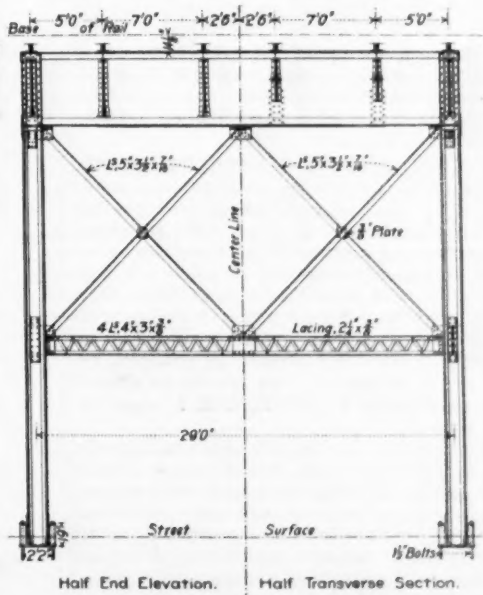
The track stringers, of which there were six, were carried by the cross-girders and were spaced 5 ft. apart under tracks and 7 ft. apart between tracks. They were web-connected to the cross-girders, the connections being constructed as shown by Figs. 134 and 135, except at the expansion joints, whose construction is described in a succeeding paragraph. The outside stringers were braced to the columns by knee braces which were connected up to girder and column in the field, as indicated by Fig. 135. It may be noted also that all of the stringers were chord-connected over the cross-girders by angle splices solidly riveted except at expansion joints.

The expansion joint construction is shown by Figs. 136 and 137. These joints were spaced every 200 ft. throughout the elevated structure, and



Half Longitudinal Section. Half Side Elevation.

Fig. 138. Longitudinal Sectional Elevation of Tower, Rapid Transit Railway.



Half End Elevation. Half Transverse Section.

Fig. 139. Transverse Sectional Elevation of Tower, Rapid Transit Railway.

came of course at cross-girders. At these points the lines of stringers have expansion joints on one side of the cross-girder and fixed joints on the other side, as shown clearly by Fig. 136. At the expansion joints the stringers are made with drop ends, the upper or projecting part of which is heavily reinforced, and takes seat on a bracket riveted to the web of the cross-girder. The brackets are formed of two angles riveted together and

having their upper ends milled. On this milled seat a half-round piece of steel 4 ins. in diameter and 3⅛ ins. long is set loosely, but is confined in its movement by two lug angles riveted to the stringer web so as to form jaws straddling the bracket web and the half-round seat. The upper or projecting part of the stringer has a half-round slot which sets onto the half-round steel piece, and it clears the web of the cross-girder by an interval of 2 ins. This construction allowed for movements due to expansion and contraction by the sliding of the half-round steel on the milled top of the bracket, and it also allowed for varying

	Stringers—Section, Web	Stringers—Section, Angles	Cross girders: Section, Web	Cross girders: Section, Flange section, Angles	Cross girders: Section, Flange section, Cover	Columns. Section, Angles	Columns. Section, Web
40-ft. span.	60″ × ⅜″	6″ × 6″ × 7/16″	60″ × 7/16″	6″ × 6″ × ⅝″	15″ × 7/16″	6″ × 4″ × ⅝″	16″ × 7/16″
45-ft. "	60″ × ⅜″	6″ × 6″ × ½″	60″ × 7/16″	6″ × 6″ × ⅝″	15″ × 7/16″	6″ × 4″ × ⅝″	16″ × 7/16″
50-ft. "	60″ × ⅜″	6″ × 6″ × 9/16″	60″ × 7/16″	6″ × 6″ × 11/16″	15″ × 11/16″	6″ × 4″ × ⅝″	16″ × 7/16″
55-ft. "	60″ × ⅜″	6″ × 6″ × 11/16″	60″ × ½″	6″ × 6″ × ¾″	15″ × 11/16″	6″ × 4″ × ⅝″	16″ × ½″
60-ft. "	60″ × ⅜″	6″ × 6″ × ¾″	60″ × ½″	(2) 6″ × 6″ × 11/16	15″ × 11/16″*	6″ × 4″ × ⅝″	16″ × ½″
65-ft. "	60″ × ⅜″	6″ × 6″ × ⅞″	.....	.....	.....	.....	.....

*Covers. (1) 15″ × 11/16″, and (1) 15″ × ½″.

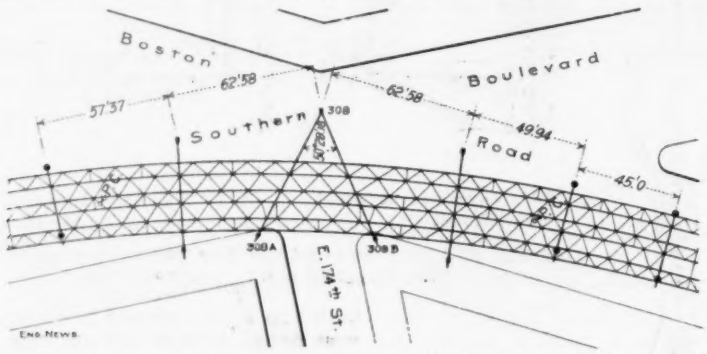


FIG. 140. PART PLAN OF CURVE AT SOUTHERN BOULEVARD AND EAST 174TH ST., SHOWING V-BENT.

inclinations of the stringers due to changes in grade, deflection, or inaccuracies of construction, while at the same time ensuring an even distribution of the load on the bracket and avoiding eccentric loading. The same expansion joint was employed on the Manhattan Valley viaduct forming Section XII. of the West Side Line, and was designed by Mr. St. John Clarke, Jun. Am. Soc. C. E., General Inspector of Designs, Rapid Transit Railway, especially for the Rapid Transit Railway work. It will be noted from Figs. 136 and 137 that the angle splices which connect the stringers over the cross-girders at expansion joints have slotted hole connections on the expansion side. The other details are obvious from the drawings.

The spans between bents or the length of the stringer girders varied, as has already been stated, from 40 ft. to 65 ft. The varying spans necessitated of course varying sections of stringers, cross-girders and columns, and these are concisely noted in the accompanying tabular statement.

The standard lateral bracing consisted of top and bottom zig-zag angles under the tracks and of top zig-zag laterals between tracks in spans adjoining expansion joints. Each pair of track stringers was connected at two points by X-braces in the vertical plane.

STANDARD TOWER CONSTRUCTION.—The standard tower construction for elevated structure is shown by Figs. 138 and 139. Each tower has four vertical columns which are braced together between their top portions on all four sides. Each pair of columns transversely of the line is connected by a cross-girder and outside longitudinal girders in the longitudinal planes of the columns connect the cross-girders. There are also four intermediate longitudinal girders or stringers between the cross-girders. The towers, as already stated, were spaced from 70 ft. to 90 ft. apart between centers.

Considering the construction somewhat more in detail, it will be observed that the tower bracing proper consists of horizontal struts with vertical diagonal bracing between them and the girders at the top of the tower. The struts are composed of double angle flanges connected by a latticed web, and the diagonals are single angles placed back to back and connected by gusset plates at their intersections. The diagonals also have gusset connections with the strut and tower girders. The diagonal system varies with the height of the towers. For towers up to 25 ft. high it consists of a single X-frame longitudinally and a double X-frame transversely, and for towers exceeding this height it consists of a single X-frame transversely and longitudinally of an X-frame, with a middle horizontal strut. The transverse girders set directly on the columns, which are planed and have cap angles to receive them. They are riveted to the cap angles and to the gusset plate connections for the diagonals and they have an outside splice plate connection with the column. The tower stringers are web-riveted to the transverse girders and have no direct connection with the columns. The outside stringers are 60 ins. deep and the intermediate stringers are 30 ins. deep. The stringers forming the spans between towers are plate girders with varying sections corresponding to the varying lengths of the span. The longest are 87 ft. and these have an 84 × ⅜-in. web and double-angle flanges of 6 × 6 × ¾-in. angles. The following tabular statement shows the stringer and girder dimensions for standard tower construction:

Span.	Stringers—Section.	Cross girders. Web section.	Cross girders. Flange section.
20 ft.	30—60 × ⅜″ web. 6 × 3½ × 7/16″ Ls.	60 × ⅜″ web.	6 × 6 × 11/16″ Ls.
25 ft.	30—60 × ⅜″ web. 6 × 3½ × 7/16″ Ls.	.....	.....
50 ft.	60 × ⅜″ web. 6 × 6 × 9/16″ Ls.	60 × ⅜″ web.	6 × 6 × ½″ Ls. 15 × 7/16″ cover.
55 ft.	60 × ⅜″ web. 6 × 6 × 11/16″ Ls.	60 × 7/16″ web.	6 × 6 × 9/16″ Ls. 15 × 7/16″ cover.
60 ft.	60 × ⅜″ web. 6 × 6 × ¾″ Ls.	60 × 7/16″ web.	6 × 6 × ⅝″ Ls. 15 × 7/16″ cover.
87 ft.	84 × ⅜″ web. 6 × 6 × ¾″ Ls.	60 × ½″ web.	6 × 6 × 11/16″ Ls. 15 × 11/16″ cover.

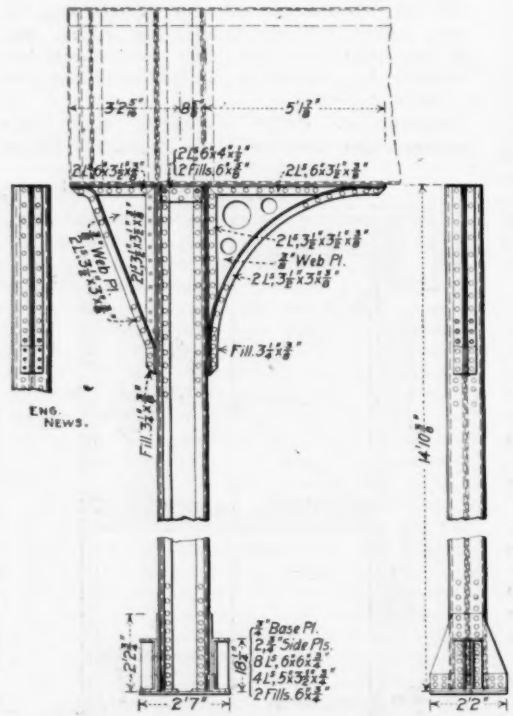


Fig. 141. Details of Columns for Open End of V-Bent.

The expansion joint arrangement and construction in the tower structure are exactly the same as in the bent structure previously described. The lateral bracing over the towers consists of top and bottom zig-zag laterals under the tracks and top zig-zag laterals between tracks. For the spans between towers each pair of track girders has two vertical sway frames and top and bottom zig-zag laterals; there is no bracing between tracks.

STANDARD COLUMN CONSTRUCTION.—A standard form of column was employed throughout the elevated structure. This column had a special section owing to the special form of angles used in its make-up. These angles had one leg finished with a bulb edge. Two pairs of these angles with a plate web constituted the column, the arrangement being as shown by several of the accompanying drawings. All the columns had the same general dimensions, but their sectional area varied of course with the loading, this variation being obtained by increasing the thickness of the angles and webs and by adding cover plates in some instances. The column bases were of similar construction throughout, and their construction is shown in detail in several of the accompanying drawings. It should be noted here, perhaps, that this special bulb-angle column was used for all but the wall columns in the underground work, as well as in the viaduct structures on the surface.

SPECIAL CURVE CONSTRUCTION. — In swinging the East Side Line from Southern Boulevard into Boston Road at E. 174th St., a special curve construction was adopted. A plan of the central portion of this curve is shown by Fig. 140. The structure at this point is of the two-column bent type, and the principal feature of interest is the V-bent employed at about the center of the curve. The columns for this bent are shown by Figs. 141 and 142. The two for the open ends of

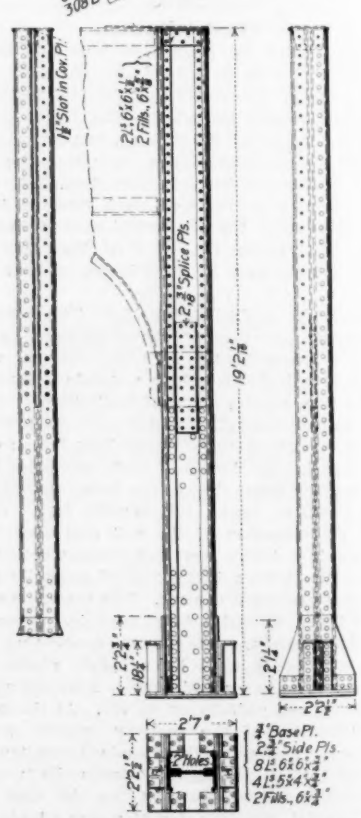


Fig. 142. Details of Column at Apex of V-Bent.

the V are identical in construction, and are like the standard column except that they carry outside knee braces to receive the overhang of the cross-girders. The column at the apex of the V is also of the standard construction, except that it is of unusual sectional area and that it receives the solid plate knee braces from two girders instead of one and thus has a double plate web throughout. Fig. 143, showing the details of the cross-girders at the apex of the V-bent illustrate the construction clearly. These girders are 58 ft. 9 15-16 ins. long and are 64½ ins. deep back to back of angles. Their webs are ½-in. thick and their chords are made up of two 6 × 6 × ⅞-in. angles and three 15 × ⅞-in. cover plates each. The arrangement of the lateral bracing is indicated in Fig. 140, and the various other details are shown by the drawings of Figs. 141 to 143.

MATERIALS.—The material used in the viaduct work was open-hearth medium steel and rivet steel. Either acid or basic steel was allowed by the specifications so long as the phosphorous content did not exceed the following percentages:

	Acid steel.	Basic steel.
Medium steel	0.06%	0.04%
Rivet steel	0.06%	0.04%

The physical requirements specified for the steel were as follows:

Kind of steel	Medium.	Rivet.
Ultimate strength, lbs.	58,000 to 66,000	50,000 to 58,000
Elastic limit, lbs.	33,000	28,000
Elongation, per cent.	20	27
Radius of area, per cent.	44	54

The requirements for workmanship were those usually demanded for first-class bridge and viaduct work.

The engineer in charge of elevated structure for the Rapid Transit Commission was Mr. Eugene Klapp, M. Am. Soc. C. E.

ELECTRIC ROCK DRILLS.*

By E. J. Munby, M. E.

At a time when electricity is being applied more and more largely to economic and labor-saving devices for all kinds of manufacturing and industrial uses, a few words about its application to rock drilling, by one who has been associated both in America and England with one of the most successful electric drills may not be without interest.

That even in an electrical age present mining practice offers an exceptional scope for the performance of drilling and other necessary operations by electricity is generally appreciated for reasons very much as follows: The use of compressed air (and of steam in such places and operations as its use is still permitted by local regulations) for operating drills, hoists, pumps, etc., has certain considerable advantages, noticeably in its assistance to ventilation in the case of the former, but is attended in both cases by the great disadvantage of the unavoidably great line loss in power transmission. This extravagant loss, from 40 to 60% under favorable circumstances and even higher where the extremes of altitude and low temperature under which mining is frequently carried on reduce compressor efficiency, may be practically entirely eliminated by the use of electricity, in addition to the far greater convenience, lower first cost and generally longer life of wires as compared with pipes.

Electricity can be used for pumping, hauling, underground traction, hoisting, ventilating and any of the uses to which compressed air is applicable, and in addition lamps can be attached at any points along the power lines, giving a safe and convenient form of light.

Where water power is available it cannot be more conveniently utilized and transmitted than by generating electricity: to take advantage of fall the power station may be at a much greater distance from the mine than would be otherwise economical, the power being, if necessary, generated at high voltage and transformed as required.

To confine ourselves, however, to the question of drilling, the smaller sizes of the electric drills on the market require only from 1 to 2 HP. to do the work for which a 2½ or 2¾-in. cylinder air drill requires from 5 to 10 HP., according to its distance from the compressor and other conditions, the electric drill, therefore, offering a great reduction in working cost, especially where, as is commonly the case in remote metal mines, fuel is expensive.

It is rarely claimed for air drills that they do cheaper work than hand drilling, their use being only for more rapid production, but for the above reasons the electric drills are said to do their work more cheaply than it can be done by hand, some makers having authenticated figures to show work done at half the previous cost of hand drilling and this is a cheap labor market.

*Reprinted from the "Stevens Institute Indicator," July, 1903.

Estimating upon the same basis of comparison of power required the first cost of an installation for electric drills should be approximately half that for the same number of air drills in spite of the fact that drill for drill the electric drills are at present more expensive, and in addition to this, actual estimates show that the total shipping weight of an electric drill plant is about one-quarter that of a corresponding air drill plant. The latter is a serious consideration when difficult or expensive overland transport to remote localities must be taken into account, added to the fact that the electric plant occupies much less floor space and requires practically no special buildings or permament masonry foundations, and the necessity for the latter has often retarded operations at a new mine until the most favorable site had been proved by development which could have been more rapidly done had power been available.

The assistance to ventilation so strongly urged by air-drill makers, as an additional advantage offered by their machines, is hardly so valuable now as in their earlier days, since their rapid dissipation of powder smoke may be as readily affected by small direct-connected electric blowers putting a barely appreciable additional load on the power line, and which supply air untainted by the lubricating oils of compressor and drill; moreover, on a large scale as in collieries, where gas is present, a mechanical ventilating system independent of drill power is

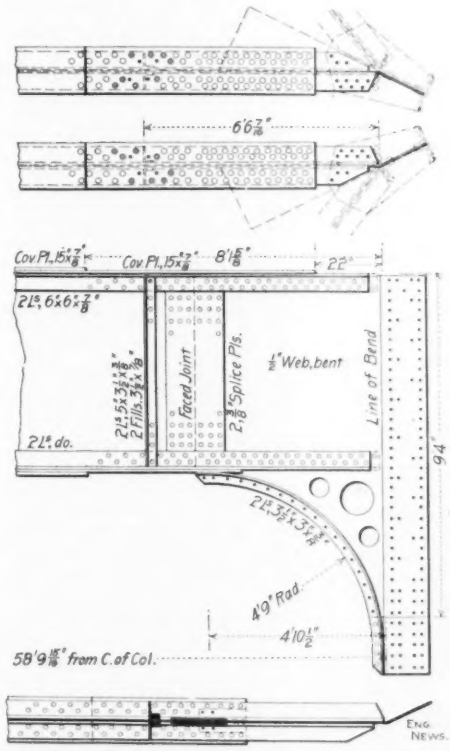


Fig. 143. Details of Cross Girders at Apex of V-Bent.

indispensable, and to take the extreme case of such deep mines as those of South Africa the stage is rapidly being reached where compressed and refrigerated air must be supplied to preserve a working atmosphere alone and which it would be poor economy to use for drilling if other power were available.

It is sufficiently obvious, therefore, from the foregoing that there exists a very considerable field of utility for a practical electric drill, and any electric drill as perfect in its way as the best air drills are in theirs would effectually put the latter out of business.

In the earliest electric drills the rock-cutting bit was either carried or struck by a plunger to which the reciprocating motion was given by magnetic coils on the solenoid principle. To obtain sufficient power these had to be heavy, and consequently awkward to handle, and as in addition to frictional heating they were subject to the electrical heating of the coils it was often necessary to have two interchangeable machines to obtain continuous operation on account of constant overheating. The best evidence that they were not satisfactory is that an electrical firm manufacturing one of the best of them has superseded its solenoid drill by a mechanical one.

Most of the so-called electric drills now on the market have got rid of the excessive weight of any one part and equally of the heating difficulty by having a mechanical drill operated by a rotary motor, in some cases carried on the same mounting as the drill, but more generally connected to it only by a flexible shaft. This motor is intentionally electric, thus making use of the aforesaid advantages of electrical power, but so long as the requisite number of revolutions of the motor counter-shaft are obtained the latter may be driven by air, water, gasoline or any convenient power. It is, however, in the conversion of the rotary to the reciprocating motion that the weak spot of electrically-driven drills is most likely to be found.

This is variously achieved by cams, by plain crank and connecting rod, by a wrist pin operating one end of a bell-crank lever the other end of which operates the plunger by a cam wrapped cylindrically round the plunger compressing a spring during three-fourths of its rotation and releasing it to give the blow, and by a crank pin with bushing cast on traveling in slotted cross bead, the slot of the latter being curved to give quick forward and slow return stroke, all of these devices being elastically attached to the tool-carrying plunger and so protected to some extent from concussion.

The only unquestionable advantage which air drills possess is that if their steel jams in seamy rock of varying hardness, the vibration sent through the machine is largely taken up by cushions of air before and behind the piston, whereas the corresponding jar to an electric drill, however mitigated by springs and washers of elastic material, or in one case by an artifical air cushion, is more likely to damage a purely mechanical contrivance.

It is claimed against electrical drills that where they do the work of air drills their advantages are more than counterbalanced by the expense of constant repairs, and this remains an obvious probability in spite of the fact that there are unquestionably electric drills in use giving every satisfaction and demanding so few repairs as not to counterbalance their advantages, and this not in the softest rock or under the easiest conditions.

For the same reason electric drills are likely to be more handicapped than others by mishandling; rock drills are proverbially used with less care than any other machine, the average miner attempting to restart them when stopped with a blow from a sledge hammer, and electrical machinery is generally considered to require cleanliness and careful handling. Where the air drill makers have been 20 years in the market and have made their machines as nearly fool-proof as possible, they have a long start, therefore, over machines with obvious theoretical advantages until time has elapsed for a class of sufficiently educated electric drill runners to have grown up.

These difficulties, however, will be—are being—eliminated and the electric drill is bound to come.

Admitting the air drill to be more unbreakable than the electric drill in its present form, both sides claim to have beaten the other in actual inches per hour or feet per day drilled, and of the few actual competitive trials that have taken place, one has probably been successful as often as the other; this, however, is rather beside the point, as it has been sufficiently shown that if an electric drill can be proved nearly as good as an air drill and equally wear-resisting, the economic advantages are decidedly in favor of the former.

Enough has been said, however, to indicate that if the electric drill is to be a commercial success it must not be left to demonstrate its own good points to miners, who will examine it with a double-hand manner if it puzzles them. It is by no means intrinsically more difficult to handle than an air drill, and there is no reason why, if properly handled, it should be more delicate, but if it is to compete with 20 years' experience in air drills it must be backed by more patience and capital than a new machine usually requires, that its proprietors may be able to accept any kind of challenges, sell on approval—of two or three months' duration, if necessary—during which their machines should be run by their own men or under their supervision, so as to convince themselves and their clients that they have got hold of the right article which, with reasonable care and attention, will do all that is expected of it.

THE NOISE OF ELEVATED RAILWAYS has been causing trouble in Berlin, Germany, and the Berlin Underground & Elevated Electric Ry. Co. has tried various experimental methods to prevent this serious objection. The method which has been adopted, and which it is hoped will prove effective, consists in laying the rails on wide and deep timber stringers or longitudinals resting upon timber ties which are laid directly upon the steel work of the structure. Special sound-deadening plates are placed between the two sets of timbers. The result is said to depend largely upon the nerves and sensitiveness of the observer. This construction has been employed on the eastern section of the line, where originally the wooden cross-ties were laid on and bolted directly to the floor beams, with the 7-in. T-rails spanning the space between. A solid steel floor of trough construction carried a filling of concrete which supported no load but served to deaden the sound. On the western section of the line, in a residence district, the 4½-in. rails are laid on wooden ties embedded in gravel ballast as a buckle-plate floor. The construction of this road was described in our issue of May 15, 1902 (pp. 392 and 397).

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The death of Frederick Law Olmsted removes the first of American landscape architects in both age and attainment. Who could ask for more beautiful monuments, devoted to nobler ends, than Central Park, Prospect Park, the Massachusetts Metropolitan Park System, the Niagara Reservation, and the breathing and ornamental spaces of scores of municipalities, institutions and private estates? Few men have had the good fortune and the ability to give so much and such varied service as did Mr. Olmsted, and few have had the support of such able and talented assistants as did he. His career has many lessons for the engineer, of which only two will be mentioned here: He studied and adapted nature to the needs of man, never forgetting the esthetic; and in developing the esthetic he ever kept in mind utility.

For the second time the opponents of municipal ownership in England have been disappointed through the failure of a Joint Parliamentary Committee on Municipal Trading to bring in any definite recommendation on the subject. The character of the two committee reports thus far made is briefly indicated elsewhere in this issue, and in the same place a comprehensive abstract of the report made a few weeks ago is given. The long and short of it is that the questions at issue are so large and complex, and so vitally affect the municipal public, on the one hand, and large industrial and financial interests, on the other, that no Parliamentary committee would dare, even if it desired, to dispose of the subject summarily. The first committee rendered good service by bringing together a large volume of testimony on both sides of the question, and the more recent committee has brought out clearly the need of a good system of municipal accounting, uniform so far as feasible, subject to competent, uniform audit under central direction or control. Some beginnings of general reform in municipal accounting have been made in the United States, particularly in Wyoming and Ohio. In the latter State the uniform classification of accounts devised by a committee of the National Municipal League has served largely as a model, and a few cities in other States have voluntarily adopted some or all of the features of the League schedules. Proper municipal accounting is essential to a thorough study of municipal ownership in a given community, and uniform accounting is at least highly desirable, if not also essential, to any comprehensive general study of municipal ownership as a condition, rather than a theory.

In another column of this issue we illustrate two examples of viaducts constructed to carry railways along city streets. One of these structures forms a part of the Metropolitan rapid transit railway of Paris; the other is a part of the Rapid Transit Railway now in process of construction in New York city. The purpose of these two viaducts, their capacity and the traffic which they are designed to accommodate, are substantially alike, but in all other respects the two structures are radically different. The question that arises is, what reasons led the French engineers to evolve a type of construction so radically different from the American? Certainly it has no great superiority, considering the structure merely as a tool for transportation. In this respect the elevated line of the New York Rapid Transit Railway is quite as efficient and it is, moreover, a much cheaper structure. It is probable that we must look for the reason in the often lauded desire of the foreign engineer to secure greater beauty in his structures. Indeed, the fluted columns with their ornamental capitals, the sculptured masonry piers, the curved lattice girders and the frequent use of ornament are all pronounced efforts to beautify the French viaduct. Have they succeeded in doing this? Is the Paris elevated road a handsomer structure than the simple and cheaper viaduct of the New York rapid transit line? It will be difficult, we think, to convince American engineers that it is or that the use of ornamental cast-iron and carved stonework will compensate for the light shut off by closely latticed trusses and solid floors. There has been much written concerning the æsthetics of bridge design, and American engineers have been repeatedly haled to the bar for their transgressions in this regard. Doubtless they have deserved this correction. In any event, we do not feel that we hold a brief for their defence against such charges and shall not attempt to defend them here. We may remark, however, that if after his years of artistic precedent, this structure is the best that the French engineer can do in designing a handsome elevated railway, the American engineer has little cause to regret that he has confined his attention to developing a form of construction whose principal object has been to attain simplicity, cheapness and suitability to its purpose.

Probably the largest contract for nickel steel since the days when that material formed the armor plate of all war ships will be awarded this month, when the contracts are let for the new Blackwell's Island Bridge across the East River at New York city. The specifications and some of the contract drawings for this structure are published elsewhere in this issue. According to the engineer's estimates accompanying these drawings there will be 42,965 tons of steel in the bridge, of which 4,500 tons will be 3½ per cent nickel steel, which will be used exclusively for eye-bars and pins. The items going to make up this aggregate of 42,965 tons of steel are worthy of note, and we give them here as follows:

	Pounds.
Nickel steel eye-bars and pins	9,000,000
Structural steel eye-bars and pins	6,390,000
Riveted girders	23,024,000
Towers, chords, columns and struts	41,777,000
Rolled I-beams and channels	1,000,000
Buckled plates	4,650,000
Total	85,931,000

The aggregate itself is worth comparing with the total of steel employed for some other large structures with which our readers are acquainted. In building the Manhattan section of the New York Rapid Transit Railway, 74,326 tons of structural steel were contracted for by a single firm. This, we believe, is the largest single contract ever awarded for structural steel. The superstructure and foundations for the Forth Bridge in Scotland contain about 73,440 tons of steel, which was furnished by several different steel makers. In building the Williamsburg Bridge across the East River at New York city about 47,000 tons of steel will be used. This material was also supplied by a number of different firms. The Memphis Bridge, which is one of the largest bridges in the world, consumed 8,160 tons of steel, and the Park Row Building in New York city, which is the highest and one of the largest steel skeleton buildings in existence, has 9,000 tons of steel in its framework and foundations. None of these structures contain any nickel steel, however, and this fact makes the Blackwell's Island Bridge a distinctively noteworthy structure. It should be noted, however, that the plans for the Manhattan Bridge call for some 13,000 tons of nickel steel for the eye-bar chain cables.

A paper giving an analytical summary of the nature and causes of a large number of dynamo and motor breakdowns is reprinted elsewhere in this issue. The observations covered by the summary presumably all relate to direct-current machines in regular commercial service. Indicating, as it does, the elements of weakness in the construction of such machines and suggesting as to the causes productive of such weaknesses, the paper is of great value, the more so because such information is exceedingly rare. The fact that it is in this case derived from British practice should not greatly affect the conclusions which may be drawn from the paper; for even if it be held that differences in the general construction of American and British machines cause a difference in the frequency of breakdowns, there is no reason for believing this to affect the relative share of different parts of the machine in contributing to failures.

The attention of electrical engineers is so largely given to alternating-current working and similarly attractive subjects that the old direct-current machine receives little more than perfunctory consideration. A paper like that under discussion serves to show that there is still much about its construction and operation that is worth study. For instance, the first table given by the author shows that in the long run the armature is damaged more than twice (2.3 times) as frequently as is the commutator. This figure does not fully represent, however, the relative share of the two parts in causing trouble, for the second table shows that breakdowns originate in the armature more than three (3.2) times as often as in the commutator. These figures are worth remembering in connection with the great amount of abuse which has been heaped on the commutator of direct-current machines. According to Table II., in the paper, the armature caused 48% of all the failures, from which at most 4% can be subtracted for machines over-rated, over-loaded or otherwise unsuited for their service. This leaves, of all failures which occurred, 44% chargeable to the armature per se.

Without going further into the study of the tables given by the author, we would briefly call attention to two matters of more general moment which they suggest. As shown in Table III., one-third (32%) of all the failures were of such character that the author felt justified in attributing them to bad design or bad workmanship, the former cause being charged with over half of the number. This proportion is rather surprising. We may assume that the machines represented, or at least the large majority of them, were modern machines. As such they had the advantage, in their design, of a well-developed theory and a large accumulated stock of experience, as compared with motors and dynamos built fifteen years ago. If in spite of this we find that one failure in five is due to poor design, and

one in every three is charged to either faulty design or poor execution, we are tempted to conclude that much careless or even incompetent work in direct-current machines is put on the market, possibly because of the very fact that practice in this field has crystallized around fairly definite standards.

The second matter which we desire to note is the fact that about half of all the breakdowns resulted from failure of the insulation in some part or other of the machine (Table II.). This calls to mind and confirms the recognized fact that insulation is the weakest detail in electrical engineering. The demands which are put on insulation by the necessities of construction and operation are sufficiently severe, and in addition there is a slow deterioration with age, in producing which, heat, moisture and mechanical forces all play a part. The author of the paper in one place says "the writer looks upon this (the deterioration of insulation under normal conditions of working.—Ed.) as bad design, because it is the use of unsuitable materials or of materials under unsuitable conditions;" but in view of the gradual deterioration which all machine-insulation undergoes, his conclusion, it would seem, does not necessarily follow. We may recall in this connection that a good statement of the requirements to be fulfilled by an ideal insulating-material was given by Mr. M. von Recklinghausen in a paper read last Spring before the American Electrochemical Society, and printed in Engineering News of April 23, 1903. That statement leads to the conclusion that for general insulating purposes, and particularly for machine-insulation, there is as yet no satisfactory material available. Until such a one is invented it is well to bear in mind that the insulation of electrical machinery is subject to many and varied diseases, the effects of which are apt to appear suddenly and inconveniently rather than otherwise.

LINING WATER-WORKS TUNNELS IN SHALEY ROCK

Should water-works tunnels in rock be lined where the rock is shaley? This is one of several interesting questions raised at Troy, N. Y., as set forth elsewhere in this issue. It is, of course, impossible to lay down any hard and fast rules to govern methods of construction, where earth and rock excavation are involved. Mud passes by insensible degrees into hardened clay, clay into shale, and shale into slate; and in a similar manner sand passes into sandstone or even to quartzite. There is no written definition of rock that will clearly and unquestionably distinguish it from earth, for rock materials are found in all stages of transition from soft to hard, from loose to compact.

It is not surprising, therefore, that experts differ when called upon to interpret specifications involving classification of rock, nor that they differ as to the necessity of lining tunnels, where the question is one of rock hardness. A study of the three reports under discussion will show that at least two engineers were largely influenced in their decision by the fact that Hudson River shale goes to pieces when exposed in small fragments to the action of the elements. It may be granted that many shales, and in fact all stones having a thin laminated structure, are not durable; particularly when under full exposure to the atmosphere and to the sun. Sandstone tombstones in both Trinity churchyard and Grace churchyard, New York, are badly decomposed; and this decomposition has taken place for the most part by the successive flaking off of laminations. The same is true of many of the stones in the outer walls of the churches themselves. A most striking feature in the latter case is that the stones facing the south have been eaten into with far greater rapidity than those facing the north. This is particularly noticeable in the archway entrance to Trinity Church. The tombstones also have scaled off to the greatest extent on the sides facing the afternoon sun; that is, facing the west. Not only in these places but also in many others does close observation show the weathering action of the sun. Of course, this action arises from the unequal heating, and consequently the unequal expansion, of the stone. When shale is exposed the disintegration from this cause is obviously far more rapid, because of the low adhesive, or cohesive strength of adjoining laminations. The freezing of water in the exposed stone may also have its effect, although it is now claimed by some that this effect is secondary in importance. But in either case, exposure to changes in temperature is the great cause of rock disintegration.

The acids in coal smoke, when dissolved in water and so brought in contact with stone, have a very decided disintegrating effect, especially upon rocks containing calcite, or limestone. In a railway tunnel this acid factor is certainly one not to be lightly dismissed, where the rock is at all calcareous and shaley. But in a water tunnel, unless the water contains an abnormal amount of vegetable acids or CO_2, is not chemical disintegration of the rock too unimportant to merit serious consideration? If so, there is left only the temperature factor. Changes in the temperature of water in a conduit remote from the action of the sun are so slow, and within such narrow limits, that in a water tunnel always kept full, it would seem as though they need not cause the slightest apprehension as to the durability of the submerged rock. In support of this, reference may be made to the unlined water tunnels cited by Professor Raymond elsewhere in this issue, but an even better proof is to be found in the bed of the Erie Canal. Mile after mile of the Erie Canal has been excavated through soft shale, and up to the recent deepening this material had not disintegrated during thirty or more years of exposure to the water in summer and to the snow and ice in winter. In sounding for rock on one section of the canal, a member of our editorial staff found this soft shale apparently as hard as the day of its original exposure; yet, when it was excavated and dumped in fragments on the spoil banks, it began to go to pieces at once; and the disintegration proceeded so rapidly that in a few months much of the spoil looked more like clay than like shale.

These facts seem to weaken the argument that a water tunnel should be lined merely because the rock shows a tendency to disintegrate upon exposure. Where a water tunnel has been excavated with small charges of powder, and has been thoroughly tested by sounding for loose layers, so that at the completion of the tunnel every part of the roof is sound (even though soft), may it not be depended upon to remain sound? No conclusions as to the performance of unlined shale can be drawn from railway tunnels, for the jarring of passing trains and the exposure to coal gases are conditions not met with in a water tunnel. Thus, in railway tunnels that have been in use 40 years or more, the brick lining frequently scales off in large sections, but is there any record of the failure of an old brick lining in a water tunnel?

In reasoning by analogy there is always great danger in not giving due weight to even apparently slight variations in conditions. Rock within a tunnel differs from rock without; rock submerged differs from rock exposed to the air; and even the direction that a tombstone faces will largely determine its life.

Reverting, in conclusion, to the Troy tunnel, we do not wish to be understood as expressing an opinion on that controversy, further than our remarks may apply to all water-works tunnels under similar conditions. The degree of softness and seaminess existing in the new tunnel in question has been passed upon by the four engineers already quoted, and it would seem presumptuous for any one who had not been on the spot to do more than point out some general conditions bearing upon the questions at issue.

SOME RECENT FEATURES OF ELECTRIC RAILWAY TRANSPORTATION.

The remarkable development of electric railway transportation within the past few years is a matter which may well call for attention at this time. The rapidity and the varied phases of this development are in many respects unparalleled in the records of the earlier development of steam railways. The use of sleeping cars on electric railways is about to become an established fact, and is one of the latest movements in this system of transportation. This step, and the length of continuous line which makes such a service practicable, may well lead the managers of steam railways to wonder how far the competition of electricity with steam will be carried in the field of railway transportation.

When suburban and interurban electric lines first began to compete with the steam railways, it was very generally claimed that the competition would be purely in local traffic, as the lines were short and the companies small. But electric railway development has followed a similar course to that of steam railway development in earlier years. Short lines have been lengthened and connected up into systems, and small companies have been absorbed by large companies owning these systems. The service is as yet almost entirely for passenger traffic, a few roads carrying express and light freight, and a very few others also carrying a limited amount of heavy freight. The freight traffic, however, is a very secondary consideration, except on purely local lines, and the conditions of operation make it impracticable to handle a regular and concentrated freight traffic, such as that of steam railways.

The competition in local passenger service has been severe, but the steam railways have not suffered as much as might at first be supposed, even from parallel electric roads. The reason for this is that the electric railway, with its lower fares, more numerous stopping points and more frequent service, develops a new traffic which the railway never could or would have developed, and this is particularly the case with short or station-to-station journeys. Thus the electric railway has by no means to depend entirely (or even in large degree) upon traffic which it can take away from the steam railway. On the other hand, it has been found in certain cases that the electric railway indirectly benefits the steam road. Increased travel leads to increased business and trade, and this in turn causes an increase in freight traffic and long-distance passenger traffic.

Electric lines of 25 to 40 miles in length are already quite numerous, and many of them parallel steam railways for considerable distances, so that their relations to the latter are beginning to be fairly well understood. But electric lines of 175 to 200 miles, with a sleeping-car service, may develop a much more serious competition with existing steam railways. More than a year ago a service of this kind was projected on a series of electric lines between Cleveland and Detroit (about 180 miles), but financial reverses led to the abandonment of the project at that time. The route on which a sleeping-car service is to be established in September is that between Indianapolis, Ind., and Columbus, O., being formed by a number of connecting lines which are part of a large system controlled by a syndicate. The distance by this route is about 190 miles, as compared with 185 miles by the Cleveland, Cincinnati, Chicago & St. Louis Ry., and 188 miles by the Pennsylvania Lines. We are not informed as to the time schedule for the sleeping cars, but it should not call for very high speed, as passengers would not wish to start very late at night or to arrive very early in the morning. The charge is to be $2 per berth, or $3 for a section. The berth rate is about the same as on the sleeping cars of the steam railways between the same points, but the fare on the electric road is only about half that on the steam roads. It will certainly be of interest to see how successful the electric car service proves, and what effect it will have upon the through and sleeping-car traffic of the competing steam railways. It may be noted in this connection that on these latter the sleeping-car service is often inconvenient for cities or towns only 150 to 200 miles apart, the service between the terminal cities of the train's run being the first consideration. So that here again it is possible that the electric cars may develop a special traffic of their own.

One difficulty which seems liable to be encountered in the electric sleeping cars is that of noise and vibration. These cars will be smaller and lighter than the ponderous cars operated on steam railways, and as they will be run singly they will naturally ride less easily and steadily than where cars are coupled up in a train, each car being then restrained more or less by the adjacent cars.

This has been the experience with ordinary cars on many electric roads where even moderately high speed is maintained, even on a particularly substantial track. On these single cars a rough spot in the roadbed, a low joint or an irregularity in curve or curve entrance produces much greater degree of swing, lurch or shock than is experienced by cars coupled in trains. In very few cases are electric railways operated by trains of two or more cars. Another cause of noise and vibration will be in the motors and gearing, for unless a very special system of gearing and of floor construction is introduced it will be extremely difficult to avoid the buzzing sound of high-speed motors. This is often noticeable in ordinary cars, and would be more serious and troublesome in a sleeping car.

The sleeping cars themselves, which were briefly described on p. 173 of our issue of Aug. 27, are worthy of some attention for two reasons: In the first place, they are combination cars, the intention being for each car to run in one direction by day as a parlor car (with 20 revolving chairs), and to return by night as a sleeping car (with ten sections). In the second place, the partitions are of the flexible wooden rolling curtain type, and the partitions not only separate the sections, but also shut them off from the central aisle, leaving only a narrow doorway, over which is hung a curtain or portiere. The berths are only wide enough for one person, so that there is an open space between the berth and the partition. While this is but a narrow space, it gives much better accommodation for the passenger in dressing and undressing than is afforded in the ordinary sleeping car, where the sections are screened from the aisle only by curtains hanging against the sides of the berths.

A large majority of the electric interurban railways have a single track, with passing places, and in view of the high speeds and frequent service it is essential that means be taken to secure safety in operation. There has so far been but a limited application of the block system and block signals, but great reliance is placed on the telephone dispatching system. Under this system, which has been described in our columns, the cars are run by a regular schedule or time-table, and the conductors report by telephone to the dispatcher at certain points. If a car loses time or is ahead for any reason, or if a car arriving at a passing place finds that the opposing car is late, the dispatcher is communicated with and special orders are obtained. The cars usually carry portable telephones, and the telephone wires are led down to poles at intervals of about half a mile, so that in case of accident, breakdown, or other emergency, the conductor can readily effect direct communication with headquarters.

The safety of this system, of course, depends largely upon strict discipline and a strict obedience of orders. These conditions did not obtain on the earlier electric railways, and haphazard methods of dispatching, coupled with irresponsibility and recklessness of motormen in trying to "steal a switch" or make up time, have been the cause of many serious accidents. At the present time, however, the system of discipline on many of the important electric railways is almost as strict in principle and practice as that of first-class steam railways.

In view of the high speed and frequent car service of electric interurban lines, it is strange that the companies should so often try to insist upon crossing steam railways at grade. At all such crossings a complete system of interlocking signals and derails or stops is essential, but no such protective system is as sure a preventive of accident as a physical separation of the grades. The interlocking plant, also, will cause occasional delays and blocking of cars, while the cost of its installation, operation and maintenance (the larger part of which is usually required to be borne by the electric railway) may easily exceed the expense of the construction, maintenance and repair of an over or under crossing. It seems probable that in many cases where these grade crossings are insisted upon, the action is not taken at the instance of the engineers, but is due to the arbitrary decisions of the promoters, who may very likely have little comprehension of the practical or economic questions involved. In some States, the matter of establishing grade crossings of this kind must be submitted to the Board of Railroad Commissioners or similar authority.

Grade crossings of streets and roads seem to be regarded as a matter of course, and in general very little attention is paid to the protection of users of the highway. A small sign is often the only warning, while the car whistle is sounded more or less regularly. The speed and frequent service of cars, however, make it highly desirable that some more efficient warning should be given, especially as the cars make so little noise. An electric bell or other audible signal at the crossing, and the provision of a loud whistle or gong on the car might meet the requirements, care being taken to ensure that motormen strictly obey instructions as to sounding the whistle or gong. At night, the beam of light from the powerful electric headlights now frequently used on the interurban roads, is a good warning of the approach of the car.

With no heavy freight trains to be considered, electric railways may be built with steeper grades and a more irregular profile than steam railways in the same district, in order to reduce the cost of construction. Very sharp curves are also frequently used, often on account of right-of-way limitations, as pointed out in our issue of March 5, 1903. The cost of construction is also comparatively low from the fact that large yards and terminal facilities are not required, the stations are simple and inexpensive, and there are rarely any very severe engineering difficulties encountered or important structures required.

One other point to which we may refer in connection with the development of electric railway transportation is that of terminal facilities and stations. It was at one time claimed that no city terminals would be needed, as the interurban cars could stop at their connecting points with the city street railway lines and transfer their passengers. Passengers, however, do not regard such transfers with favor, and such an arrangement would not be convenient for the express and package freight service; and as a matter of fact interurban cars are usually run quite to the central districts of the cities which they serve. Sometimes the car makes a circuit through the streets, or it may run to a terminal spur in a side street. As it is advisable to provide waiting accommodations for passengers where cars are run, perhaps, at 30-minute intervals, stores are frequently rented and fitted up as waiting rooms. In a few cases terminal buildings have been erected, into which the cars are run, and these provide for both passenger and freight traffic. With a sleeping-car service, such stations will be practically necessary to meet the ordinary convenience of passengers. In one city, however, an attempt has been made by property-owners to prevent the running of interurban cars on a city street. It is claimed that while a street railway may be permitted, the interurban lines is a "commercial railway," affording no local service (as its cars do not carry passengers from point to point within the city), and being therefore regarded as an obstruction. Whether the complaint will be pressed remains to be seen.

From past experience and present conditions it is very evident that the electric railway has now become of sufficient importance to be classed as a special system of transportation, and not regarded as a mere extension of the city and suburban railway. What further advances the future may bring cannot safely be predicted, but it is very certain that electric railway transportation has by no means as yet reached its full development.*

*For the convenience of those who may wish to look up this subject of interurban electric railway transportation we give the following list of some of our principal articles on this particular subject:

"Economic Railways for Country Districts"..Feb. 1, 1900
"Oshkosh & Neenah Interurban Electric Railway." ..... April 5, 1900
"Electric Railway Construction and Operation" ..... Aug. 29, 1901
"Chicago & Joliet Electric Railway"..... Oct. 24, 1901
"Terminal Problems of Interurban Electric Railways" ..... Oct. 31, 1901
"The Electric Motor in Competition with the Steam Locomotive" ..... Nov. 14, 1901
"Construction and Operation of Electric Interurban Railways" ..... Jan. 30, 1902
"Construction and Operation of the Grand Rapids, Holland & Lake Michigan Ry". Mar. 27, 1902
"Article on Electro-Pneumatic Traction System" ..... July 3, 1902
"The Third-Rail and Trolley-Wire Systems of Electric Interurban Railways"..... Aug. 14 and Oct. 2, 1902
"Electric Traction System Using Single-Phase Alternating Current (Washington, Baltimore & Annapolis Ry.)"..... Oct. 2, 1902
"Aurora, Elgin & Chicago Electric Interurban Railway"..... Oct. 9, 1902
"Express and Parcel Freight Service on Electric Railways" ..... Oct. 16, 1902
"Signals for Urban and Interurban Railways" ..... Oct. 16, 1902
"The Interurban Electric Railway System of the Union Traction Co., of Indiana"...Nov. 13, 1902
"Terminal Station for Electric Interurban Railways at Cincinnati." ..... Jan. 29, 1903
"The Legal Status of Interurban Electric

LETTERS TO THE EDITOR.

The Most Northern Railway in the World.

Sir: I had supposed that the White Pass & Yukon Route was the most northern railroad or railroad system in the world until I saw in the "Revue de Paris" for July 15 an account of the new railroad across Lapland.

This line, running from the north limit of the Gulf of Bothnia, via Gellivara, to the new port of Narvik, on the Ofotenfjord, opposite the Loffoden Islands, passes the line of 68° N. latitude, while the White Pass Railroad is below 60°.

The account of this new thoroughfare is interesting reading.

Yours, C. E. W.

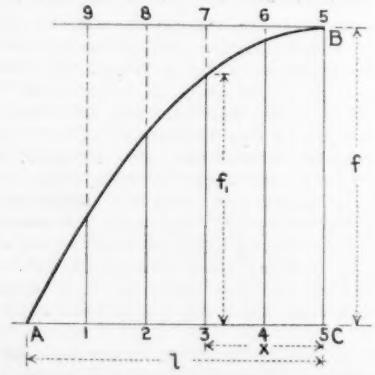
Buffalo, N. Y., Aug. 24, 1903.

A Simple Method of Constructing a Parabola.

Sir: In giving the following construction the writer lays no claim to novelty, as the method is old, but one certainly not generally known as it deserves to be for its elegance and simplicity compared with other usual means of producing the same result. The writer's own experience leads him to believe that he will be doing a service to a large number in publishing it.

The problem is to run a parabola, whose vertical axis is B C, through any two points A and B. Draw the horizontal A C and divide it into any number of equal parts, say 5. At the points of division erect perpendiculars. Number the points as given in the figure. Always start with zero at A and repeat the last number on the lower line on the upper, after which continue numbering the upper line as shown. Then if B C is equal to unity or $\frac{25}{25}$, the next ordinate of the parabola is $\frac{6\times4}{25} = \frac{24}{25}$ of B C, the next $\frac{3\times7}{25} = \frac{21}{25}$, the next $\frac{2\times8}{25} = \frac{16}{25}$ and the last is $\frac{9\times1}{25} = \frac{9}{25}$ of B C. This gives, as will be seen, a very easy and rapid method of constructing a parabola which has also the merit of being strictly accurate, as shown in the following proof:

Let the distance A C = 1 and let the number of parts



Simple Method of Constructing a Parabola.

into which A C is to be divided = n. Let it be required to find the ordinate at a point x distant m parts from C. Also let the last ordinate = f and the ordinate at x = f_1. Then a being the length of a division we have l = a n and x = a m. Now by the law of the parabola,

$$l^2 : x^2 = f : f - f_1$$

or

$$\frac{l^2}{x^2} = \frac{f}{f - f_1}.$$

By our construction, $f = n \times n = n^2$ and $f_1 = (n - m)(n + m) = n^2 - m^2$.

Therefore

$$f - f_1 = m^2 - (n^2 - m^2) = m^2,$$

and

$$\frac{f}{f - f_1} = \frac{n^2}{m^2},$$

But $1^2 = a^2 n^2$ and $x^2 = a^2 m^2$.

Therefore $$\frac{1^2}{x^2} = \frac{a^2 n^2}{a^2 m^2} = \frac{n^2}{m^2} = \frac{f}{f - f_1},$$

which proves that our construction is theoretically correct for any number of equal parts into which A C is divided if the system of notation given above is followed. In conclusion the writer would state the proof given here is original with him, while the method was shown him some time ago without a proof of its correctness.

Henry Szlapka, Consulting Engineer.

Narberth, Pa., Aug. 5, 1903.

Soundness Tests of Portland Cement.

Sir: As the paper by Mr. W. P. Taylor before the American Society of Testing Materials, on the Soundness Tests of Portland Cement (printed in our issue of July 23, and noted editorially in our issue of July 30.—Ed.) has brought forth considerable discussion, it occurs to me that the results of some tests that I have lately made may be of interest to your readers.

These tests extended over a period of eight months. The cement was received at the laboratory in good condition on Jan. 3 of this year and tested as follows:

Fineness.—Passing No. 50 sieve, 100%; No. 100, 91.7%; No. 200, 75.2%; initial setting, six hours.

Tensile Strength (average of 5 tests in each case).

	Neat.	1 to 3.
7 Days	641 lbs.	98 lbs.
28 Days	689 "	296 "
3 Months	807 "	403 "
6 Months	582 "	401 "

Accelerated Tests for Soundness.—Pat; 24 hours old in air, went to pieces in steam in less than four hours. Briquettes; one day in air, six days in water, also went to pieces in steam in less than four hours.

The briquettes after six months in water disclosed no sign of failure except the noticeable decrease in strength indicated above and an irregular fracture on breaking. On Aug. 1, or one month later, the briquettes that had been kept in water for the twelve-month tests showed considerable checking and swelling, and on Aug. 17 were found to have gone to pieces entirely.

The 1 to 3 briquettes are still under observation and so far show no outward sign of failure.

I do not wish to enter into any discussion of this interesting subject at this time, but present these facts as I have found them.

Yours respectfully,

P. C. McArdle,

Director of the Chicago Testing Laboratory.

Chicago, Ill., Aug. 25, 1903.

A Novel Tilting Pile Driver.

Sir: It is with considerable interest that I read your article on pile driving in the editorial column of your paper of July 2; and I note what you say with reference to improvement, not in handling the hammer quickly, but in the art of getting the machine over the pile or the pile in the leads; that is where the time is saved in pile trestle work.

I send you drawings and a view (Figs. 1 and 2) of a traveling overway pile driver, which is positively an original idea of my own. You will see that this overway driver is rigged to drive batter piles not to exceed 2 ins. batter to the foot, which it does fully as easy as driving plumb piles. This is done by means of a bolster on which the leads are placed, having a screw at each end with a ratchet-nut N, Fig. 1. When it is desired to place a pile on a batter, a man is placed on each screw, one running up while the other is running down, hence laying the machine over to the desired batter. When the pile is driven below the leads the machine is at once racked sideways by means of a ratchet wheel W, connected to a shaft, S, running the entire length of the machine (48 ft.), which shaft is in turn connected to pinions P, which mesh into rack-rails. It will be seen by the illustration that the engine as well as the leads are mounted over this shaft and pinions, the pinions being shrouded with rollers, R, which bear on the track to prevent their meshing too deep. It will therefore be seen that the machine can be moved from one pile to another very quickly, one man being able to rack sideways with ease. It will be seen that the whole machine is carried forward over standing dollies, D, six dollies being in use and two idle at all times, the idle rollers or dollies being carried forward and held in readiness to drop on the cap ahead as soon as it is in position.

This machine was designed for, and is now driving, a batter pile trestle for the Indianapolis Northern Traction Co. at Noblesville, Ind. It is equipped with a 2,600-lb. hammer, which falls on a cast-iron cap weighing 400 lbs., and is operated by a "Mundy" double-cylinder, double-drum friction clutch hoisting engine, with a 7 × 12-in. cylinder and a large boiler. The hammer is handled very rapidly. The whole device has proved a complete success and is fully up to expectations. Hoping that this may be of some use to your readers, I remain,

Yours very truly, J. H. Baer.

19 Calvin Bldg., Toledo, O., July 7, 1903.

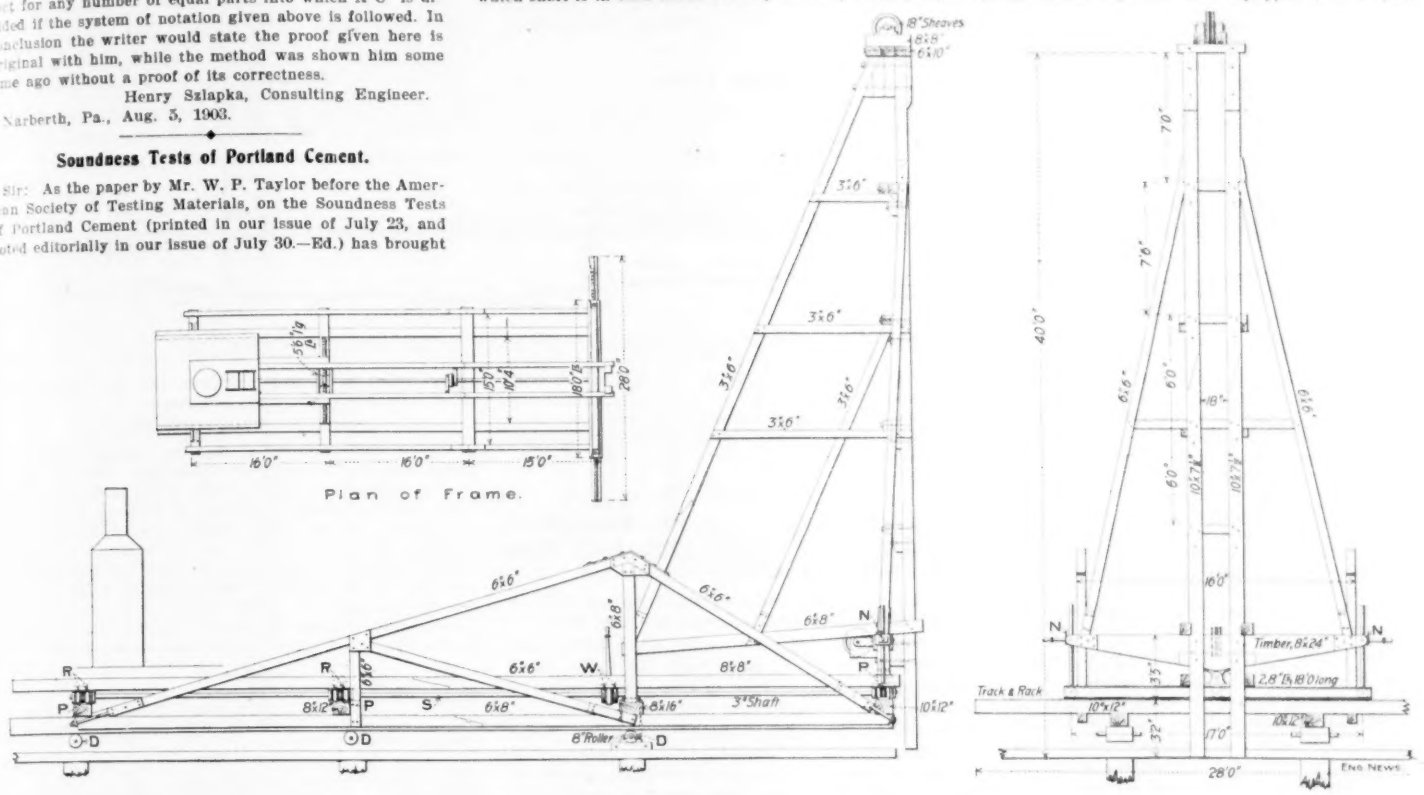


FIG. 1. A NOVEL TILTING PILE DRIVER.

Fig. 2. Driving a Batter Pile for a Trestle Bent.

(In reply to an inquiry Mr. Baer has sent us the preceding tabular statement showing the number of blows of the hammer required to drive each pile of each of four bents. The bents are numbered 24 to 27, inclusive, and there are four piles in each bent, the piles A and D being batter piles (with a batter of 2 ins. to the foot), while piles B and C are plumb piles. It is noteworthy that battering the piles does not appear to have had any material effect in increasing the number of blows required to secure the desired penetration. —Ed.)

Pile, bents.	Length, billed.	Cut off.	In structure.	Penetration.	Number of blows.	Pen. under last 5 blows	Average drop of ham.
	ft.	ft. ins.	ft. ins.	ft.		ins.	ft.
24A	26	2 0	14 0	10	31	15	25
24B	26	3 0	12 0	11	35	15	30
24C	26	1 8	12 4	12	40	10	30
24D	26	1 8	11 4	13	50	10	30
25A	28	2 0	8 0	18	38	10	30
25B	28	1 9	9 3	17	36	10	30
25C	28	2 0	9 0	17	40	8	30
25D	36	5 0	9 0	22	59	8	30
26A	30	1 8	14 4	14	38	8	30
26B	30	2 0	13 0	15	57	5	30
26C	30	2 0	13 0	15	97	4	30
26D	30	1 8	14 4	14	56	6	30
27A	30	2 0	13 0	15	67	5	30
27B	30	2 0	13 0	15	50	8	30
27C	30	1 10	13 2	15	34	10	30
27D	30	2 6	12 6	15	47	6	30

A Narrow Macadam Strip that Failed.

Sir: Relative to improving residence streets with a narrow strip of macadam, as discussed in your issues of Aug. 6 and 20, would like to say that I once had the experience of living on a street in a northern New York city that was treated in that manner, and hasten to state that the results were anything but satisfactory. The work was fin-

ished during the summer, and as long as dry weather lasted the street remained in good condition, but as soon as the fall rains commenced and the ground got softened up the street began to look entirely different, and it was not long before it was hard to believe that there was any such a thing as macadam on the street; in fact it was hardly, if any, better than other streets that were not paved.

In the spring conditions were worse, and several property owners thought they could improve matters by having gravel or broken stone spread between the macadam and the curb; the results can easily be guessed, for they very soon had a street without any crown to it, and large holes soon formed for water to collect in. It is not necessary to state that in the near future that particular street will have to be entirely repaved.

With about one-third additional cost the street could have been macadamized through from curb to curb, and when it had been done they would have had a street that would have lasted many years.

I fully agree with Professor Raymond's idea that it is cheaper to apply what money you have to a shorter stretch, or if the whole street has to be done, pave it clear through with a cheaper pavement, for I would never recommend paving a residence street with a narrow strip through the center. Yours truly,

John W. Ash, Asst. Engr., Southern Railway Co.

Rapidan, Va., Aug. 25, 1903.

(There have been scores of bridge failures, and there have been many failures of macadam, both in country roads and in streets, but the mere citation of failures of either class without accompanying data can lead to no logical deduction. To use one failure upon which to base a sweeping generalization is obviously illogical in view of the fact that under similar conditions there have been many successes. Our correspondent gives none of five important factors in the macadam work of this particular village: (1) Character of subsoil; (2) thickness of macadam; (3) quality of stone; (4) the binder and roller used in binding; (5) the amount of crown. There are other factors, it is true, but these five are probably the most important in this particular case; and of the five, the last is not the least, although it is one seldom mentioned in any citation of failure or partial failure of macadam in a village street. To keep a macadam strip clean, as we have said in a previous issue, it should have a very decided crown. On a certain village street, where an 18-ft. macadam strip was laid by a member of our editorial staff, there was one stretch having a crown of ¼-in. to the foot, and there the dirt collected until removed by scraping. But as the wearing coat was of trap, bound with limestone screenings, the macadam could in no sense be called a failure, although it was often muddy. Another section of this macadam was given a crown of ¾-in. to the foot, and was always clean despite the fact that it was in the business part of the street. On still another part of the street there were double car tracks, and the trap macadam laid between these tracks was bound with a loamy gravel, which for a long time after completion made a muddy macadam.

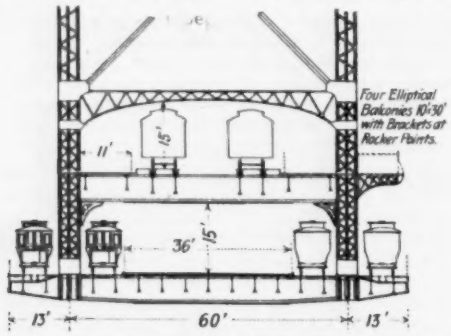


Fig. 2. Typical Cross-Section of Blackwell's Island Bridge.

It is conceded that there are streets where macadam, both in strips and from curb to curb, has proven dirty and unsatisfactory. We hope, however, that this discussion will bring forth statements as to the character of the macadam that is known to have failed, as well as statements of the conditions under which satisfactory macadam strips have been built on residence streets.—Ed.)

Notes and Queries.

A typographical error, which was probably obvious to most readers, occurred in the letter from Mr. Chas. R. Steiner, in our issue of Aug. 6, on "Steel Dams for Storage Reservoirs." Under (3) the word unreliable should have appeared in place of reliable in the sentence, "Simple rock-fill dams and earth dams are more reliable for great height at times when water should accidentally rush over the crest."

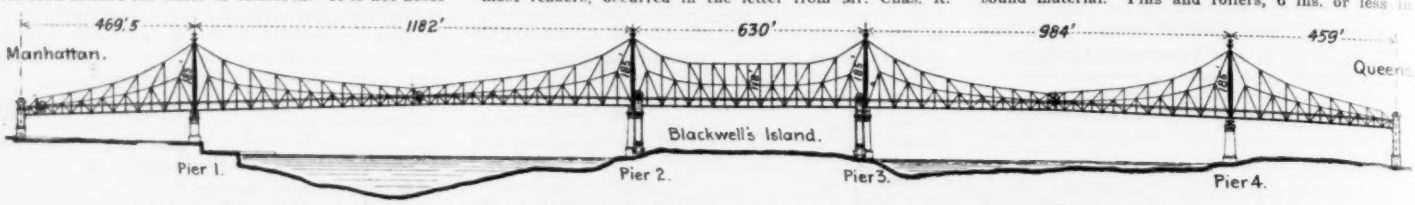


FIG. 1. GENERAL ELEVATION OF BLACKWELL'S ISLAND BRIDGE ACROSS THE EAST RIVER AT NEW YORK CITY.

THE SUPERSTRUCTURE FOR THE BLACKWELL'S ISLAND BRIDGE ACROSS THE EAST RIVER AT NEW YORK CITY.

The specifications and contract drawings for the Blackwell's Island Bridge across the East River at New York city are now ready for bidders, and bids will be received until Sept. 10, 1903. The magnitude and importance of this bridge, and the fact that it is the first great bridge in which nickel steel will be employed in large quantities, make the specifications for materials and construction of unusual interest, and we give them nearly in full in the following paragraphs. In connection with the specifications we have reproduced a number of the contract drawings, in Figs. 1 to 5, inclusive. Fig. 1 is a diagram elevation of the bridge, and Fig. 2 shows a typical cross-section, and illustrates the position of the two decks and the tracks, roadways and promenades which they carry. Fig. 3 shows some of the details of the floor and track construction. Fig. 4 shows a side and end elevation of the towers over the piers, and Fig. 5 shows some of the details of the tower construction. These drawings with the specifications explain quite clearly the character of the work, which is second in importance only to the Manhattan Bridge, whose construction has recently been so fully discussed in our columns.

GENERAL DESCRIPTION.

The work comprises the furnishing and erecting in place all steel required for the complete superstructure of the bridge except the handrailing, newel and lamp posts; provision shall be made, however, for their proper connection. The structure will consist of two lines of cantilever trusses, of a total length of 3,724½ ft., divided as follows: Two shore spans of 469½ and 459 ft., respectively; two river spans of 1,182 and 984 ft., respectively; one island span 630 ft. in length; width c. to c. of trusses, 60 ft.

The top chord will consist of eye-bars varying in width from 18 to 12 ins. The bottom chord will be of box form, to which will be built the floor system. The floor proper will be of buckled plates. The trusses will lie in vertical planes and connect to towers with inclined legs. The river spans will be hinged at their centers. Nickel steel will be used in the eye-bars and pins of the top chords and diagonal tension members, as may be ordered or approved by the Commissioner.

All steel shall be made by the open-hearth process, and shall fulfill the requirements stated further on. Sufficient discard shall be made to insure sound material free from piping or excessive segregation. The finished material shall be free from injurious seams, flaws, cracks, or defective edges, and have a clean, smooth finish. Care shall be taken in the heating and rolling of the nickel steel to prevent the formation of heavy scale. The pitting of the material, by rolling this scale into it, shall be prevented. Particular attention is called to this, as material with a badly pitted surface will be rejected. Pins over 6 ins. in diameter, whether of nickel steel or structural steel, shall be forged, and enough work put on them to insure sound material. They shall be annealed, and a hole 2 ins. in diameter drilled through the longitudinal axis, shall show sound material. Pins and rollers, 6 ins. or less in diameter, shall be of structural steel and may be either rolled or forged, and need not be annealed.

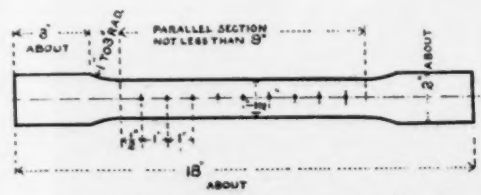


Fig. 6. Standard Test Specimen for Material for Plates, Shapes and Bars.

CHEMICAL REQUIREMENTS.

Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese (and nickel in the case of nickel steel) shall be made by the manufacturer, from a test ingot taken at the time of the pouring of each melt of steel, and two correct copies of such analysis shall be furnished to the engineer or his inspector. Check analyses shall be made of the finished material, when called for, in which case, if the sample be taken at or near the center of the section, an excess of one-quarter of the required limits for phosphorus and sulphur will be allowed. The chemical requirements are as follows:

	Phosphorus P.c. Max. Basic.	Phosphorus P.c. Max. Acid.	Sulphur P.c. Max.	Nickel P.c. Min.
Nickel Steel.				
Eye-bar pins	.04	.06	.05	3.5
Structural Steel.				
Plates, shapes, bars and pins	.04	.08	.05	
Rivet steel	.04	.04	.04	
Steel castings	.05	.08	.05	

A variation in cross-section or weight, of any piece of steel, of more than 2½% from that specified, will be sufficient cause for rejection.

TESTS.

At least one tensile and one bending test shall be made of material from each melt of steel as rolled. If the material rolled from a melt varies in thickness by ⅝-in. or more, for plates and shapes, or by ½-in. or more for bars, a test shall be made from the thickest, and also one from the thinnest material rolled from the melt. Separate tests shall be made for (1) plates, (2) shapes, and (3) bars. Additional tests shall be made if the melt is rolled at different times. Specimens for determining the tensile strength, elastic limit, per cent. of elongation, and per cent. of reduction, of material to be used for plates, shapes and bars, shall be made of the rolled material, without annealing. They shall be obtained by cutting coupons from the finished product, shall have rolled faces and both edges milled, and be of the form shown by Fig. 6. They shall have a section area of not less than ½-sq. in., and in no case shall the specimen be less than ¾-in. in width. Specimens for bending shall be cut from the material as rolled.

Specimens for determining the tensile strength, elastic limit, per cent. of elongation and per cent. of reduction, of material to be used for large pins, shall be cut from full-sized prolongations of each forging after annealing, and turned to the form shown by Fig. 7. The specimen for the bending test shall be cut from the full size section as for the tension test, and shall be 1 in. × ½-in. in section. Specimens for testing small pins shall be taken in the same manner as specified for large pins; one tensile and one bending test shall be made from each melt of steel. Rivet rods shall be tested as rolled.

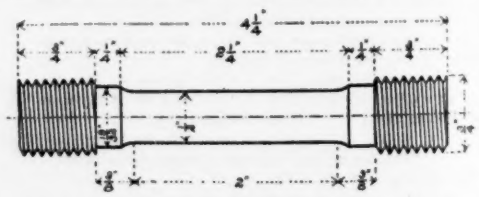


Fig. 7. Standard Test Specimen for Material for Pins.

The number of tests of steel castings will depend on the character and importance of the castings. Specimens shall be cut cold from coupons molded and cast on some portion of one or more castings from each melt or from

the sink heads, if the heads are of sufficient size. The coupon or sink head, so used, shall be annealed with the casting before it is cut off. The castings shall be true to form and free from injurious defects and blow holes.

Three bars of each melt of steel shall be ordered 18 ins. longer than required for upsetting. These pieces are to be cut off and annealed with the bars and shall be used to test the annealing. Tensile tests of structural steel showing an ultimate strength within 4,000 lbs. of that desired, will be considered satisfactory. In specimen tests, the elastic limit shall be considered the least strain producing a visible permanent elongation in a length of 8 ins., as shown by scribe marks of a pair of finely pointed dividers. For each ¼-in. above ¾-in., in thickness of material for structural plates and shapes, a deduction of 1% will be allowed from the specified elongation. Bending tests may be made by pressure or by blows.

Full size parts of the structure may be tested at the option of the engineer; if tested to destruction and proved satisfactory, such material shall be paid for at the price or prices provided in the contract for the appropriate parts, and the scrap value of such tested parts shall be deemed a proper and sufficient offset to the cost of making such tests. If the parts do not meet the requirements of the specifications, they will be deemed rejected material and be solely at the cost of the contractor. Facilities for making such tests shall be furnished by the contractor without additional cost to the city.

TABLE II.—Showing Physical Requirements for Full Size Tests of Steel for the Blackwell's Island Bridge.

Parts.	Lbs. per sq. in. Ultimate tensile strength.	Lbs. per sq. in. Elastic limit.	Elongation.	Reduction of area.	Character of fracture.	Cold bend without fracture.
Nickel Steel.						
Eye-bars	.....	.....	.....	..	.....	180° around a pin with diameter = 3t.
Eye-bars (annealed)	85,000 min.	48,000 min.	9% in 18 ft. including fracture.	40%	Mostly silky and free from coarse crystals	In the neck of the bar, 90° around pin with diameter = 2½ t.
Structural Steel.						
Eye-bars	.....	.....	.....	..	.....	180° around a pin with diameter = 2t.
Eye-bars (annealed)	56,000 min.	½ of ultimate.	10%, body of bar.	..	Fine, silky.....	.....
Angles ¾-in. or less	.....	.....	.....	..	.....	Open flat, under blows of a hammer.
Angles ½-in. or less	.....	.....	.....	..	.....	Bend shut, under blows of a hammer.

t is the thickness of the specimen.

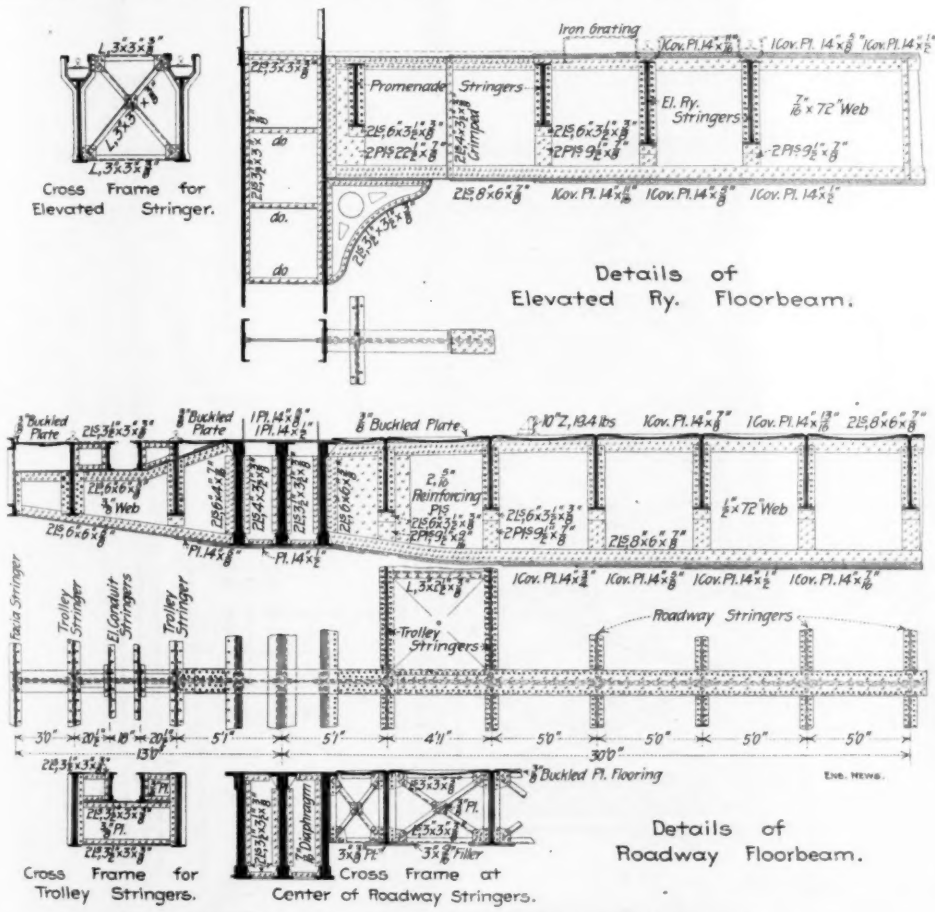


FIG. 3. DETAILS OF FLOOR BEAMS AND TRACK CONSTRUCTION.

In testing full size eye-bars for tension, should any bar break in the head, two additional bars shall be tested from the lot of bars represented, both of which shall break in the body of the bar, or, failing to do so, the entire lot shall be condemned. In full size eye-bar tests, the elastic limit shall be considered the least strain producing a visible permanent elongation in a length of 10 ft., as shown by scribe marks of a finely pointed beam compass.

Bending tests of full size angles, ¾-in. or less in thickness, shall be made when required by the inspector. The angles shall bend as described in table of requirements. (Table II.)

LOADS.

The bridge shall be proportioned to carry in addition to its own weight and that of the floor, a live load either uniform or concentrated, or both, as specified below, placed so as to give the greatest strain in each part of the structure. For the main members of the trusses and the towers: A load of 6,300 lbs. per lin ft. of bridge as "regular," or 12,600 lbs. per lin. ft. of bridge as "congested" traffic. For the secondary members of the trusses, the floor beams and the floor system: On each railroad track a load of 52 tons on 4 axles, 6 ft. + 10 ft. + 6 ft. apart (the motor ends of 2 motor cars of the Interborough Rapid Transit Co.). On each street car track either a load of 26 tons on 2 axles 10 ft. apart or a load of 1,800 lbs. per lin. ft. of track. On any part of the roadway a load of 24 tons on 2 axles 10 ft. apart and 5 ft. gage (assumed to occupy a width of 12 ft. and a length of 30 ft.), and upon the remaining portion of the floor a load of 100 lbs. per sq. ft. On the footwalks a load of 100 lbs. per sq. ft. The wind pressure shall be assumed as a moving load acting in either direction horizontally with 2,000 lbs. per lin. ft.

PROPORTIONING OF PARTS.

For the main sections of members of the trusses and towers no material shall be used less than ½-in. thick; all other material shall not be less than ⅜-in. thick. All steel work shall be so proportioned that the maximum strains from dead load and live load, or dead load and wind, shall not cause greater unit strains than the following:

	Pounds per square inch. For dead load and regular live load or for dead load and wind.	For dead load and congested live load.
For nickel steel in eye-bars and pins: Tension	30,000	30,000
Shear on pins	20,000	24,000
Bearing on diameter of pins	40,000	48,000
Bending on outer fiber of pins	40,000	48,000
For structural steel in main members of trusses, towers and bracing: Tension	20,000	24,000
Compression	$20{,}000 - 90 \cdot \frac{l}{r}$	$24{,}000 - 100 \cdot \frac{l}{r}$
Shear on shop rivets, bolts and pins	13,000	16,000

TABLE I.—Showing the Physical Requirements for Specimen Tests of Steel for the Blackwell's Island Bridge.

Parts	Ultimate tensile strength, lbs. per sq. in.	Elastic limit, lbs. per sq. in.	Elongation. Min. in 8 ins.	Elongation. Min. in 2".	Reduction of area.	Character of fracture.	Cold bend without fracture; material. Less than 1-in. in thickness.	Cold bend without fracture; material. 1-in. or more in thickness.
Nickel Steel.								
Eye-bars	90,000 to 105,000	52,000 min.	18%	..	35%	Mostly silky, and free from coarse crystals.	180° around a pin with diameter = 3 t.	
Eye-bars (annealed)	85,000 to 100,000	50,000 min.	20%	..	40%	Mostly silky, and free from coarse crystals.	Pieces of bar, not less than 4 ins. wide. 180° around pin with diameter = 2 t.	
Pins (annealed)	85,000 to 100,000	50,000 min.	..	23%	45%	Mostly silky, and free from coarse crystals.	180° around pin with diameter = ½-in.	
Structural Steel.								
Plates, shapes, bars & pins, 6" and under	60,000 desired...	30,000 min.	$\frac{1{,}500{,}000}{\text{ultimate tensile}}$	22%	..	Silky	180° flat	180° around pin with diameter = 2 t.
Large pins (annealed)	60,000 desired...	30,000 min.	Same as above..	22%	..	Silky	180° flat	
Rivet steel	50,000 desired...	½ of ultimate.	Same as above..	..	..	Silky		180° flat.
Rivet steel, nicked and bent around bar of same diameter as rivet rod	.....	.....	.....	..	..	Fine, silky, gradual break—uniform fracture.		
Steel castings (annealed)	65,000 min.	½ of ultimate.	.....	18%	..	Silky or fine granular.	90° around pin; diameter = 3t.	

t is the thickness of the specimen.

Bearing on diameter of shop rivets, bolts and pins.....	25,000	30,000
Bending on outer fiber of pins	25,000	30,000
For structural steel in secondary members of trusses:		
Tension in subverticals (hangers).....	18,000	
Compression in subdiagonals	$18{,}000-80\frac{l}{r}$*	
Shear on shop rivets & bolts	12,000	
Bearing on diameter of shop rivets and bolts.....	24,000	
For structural steel in floor system of roadway and footway and in all floor beams: Tension chords....	15,000	
Shear on shop rivets, bolts & web-plate net section.....	10,000	
Bearing on shop rivets and bolts	20,000	
For structural steel in floor system (including brackets) for railroad and trolley tracks:		
Tension chords	10,000	
Shear on shop rivets, bolts and web-plate net section..	7,000	
Bearing on shop rivets and bolts	14,000	

*Where l = length, and r = least radius of gyration, both in inches.

Bed plates shall be so proportioned that the pressure upon the bearing stones of granite shall not exceed 550 lbs. per sq. in. for regular traffic and 650 lbs. per sq. in. for congested traffic. No roller bearings shall be used in permanent details. For field riveting, the number of rivets calculated according to the preceding table shall be increased 15%. Members subject to reversals of strain shall be proportioned for each kind of strain, and the section shall be determined by the strain requiring the greater net area. Rivets, bolts and pin bearings, however, shall be proportioned for the sum of the alternate strains. For combined strains due to dead load, regular live load and wind, the unit strains given above may be increased 20%.

CONSTRUCTION.

Provision shall be made for a free expansion and contraction of all parts, corresponding to a variation in temperature of 110° F. The deflection of the spans from dead load shall be taken out by correcting the length of each truss member. The workmanship and finish shall be equal to the best practice in modern bridge works. Material shall be thoroughly straightened in the shops by methods that will not injure it, before being laid off or worked in any way. Shearing shall be neatly and accurately done,and all portions of the work exposed to view shall be neatly finished. All sheared edges in main sections of members of the trusses and towers, irrespective of thickness, and in all other material over ⅝-in. thick, shall be planed off ¼-in.

Net sections shall be used in all cases in calculating tension members; in deducting rivet holes the diameter shall be taken ⅛-in. larger than the size of the rivets. Pin connected riveted tension members shall have a net section through the pin hole 30% in excess of the net section of the body of the member, and a net section back of the pin hole at least equal to the net section through the pin hole. All pin holes shall be re-enforced by additional material when necessary, so as not to exceed the allowed pressure on the pins. These re-enforcing plates must contain enough rivets to transfer the proportion of pressure which comes upon them, and at least one plate on each side shall extend not less than 6 ins. beyond the edge of the tie plate. All sections shall preferably be made symmetrical, and the pins placed in the line of the neutral axis.

No compression member shall have a length exceeding 100 times its least radius of gyration, excepting those for bracing, which may have a length not exceeding 120 times the least radius of gyration.

Plate girders shall be proportioned on the assumption that ⅛ of the gross area of the web is available as flange area. The compressed flange shall have the same sectional area as the tension flange, but the unsupported length of flange shall not exceed 16 times its width. Web plates of girders shall have stiffeners riveted on both sides, with a close bearing against upper and lower flange angles at the ends and inner edges of bearing plates, and at all points of local and concentrated loads, and also, when the thickness of the web is less than 1-60 of the unsupported distance between flange angles, at points throughout the length of the girder, generally not farther apart than the depth of the full web plate, with a maximum limit of 5 ft. Web plates of girders shall be spliced at all joints by a plate on each side of the web, capable of transmitting the full strain through splice rivets. The flange plates of all girders shall be limited in width so as not to extend beyond the outer lines of rivets connecting them with the angles, more than 5 ins. or more than eight times the thickness of the first plate. Where two or more plates are used on the flanges they shall either be of equal thickness or shall decrease in thickness outward from the angles. Not less than 50% of the total flange area shall be in the angles wherever practicable.

The butt joints of compression members shall be connected by splices to hold them truly in position; all other joints in riveted work, whether in tension or compression, shall be fully spliced. All segments of compression members connected by latticing only shall have tie plates placed as near the ends as practicable. These plates shall have a length of not less than the greatest depth or width of the member, and a thickness not less than 1-50 of the distance between the rivets connecting them to the compressed members.

Single lattice bars shall have a thickness of not less than 1-40, and double bars connected by a rivet at the intersection, of not less than 1-60 of the distance between the rivets connecting them to the member. Angles are preferred for lacing wide members.

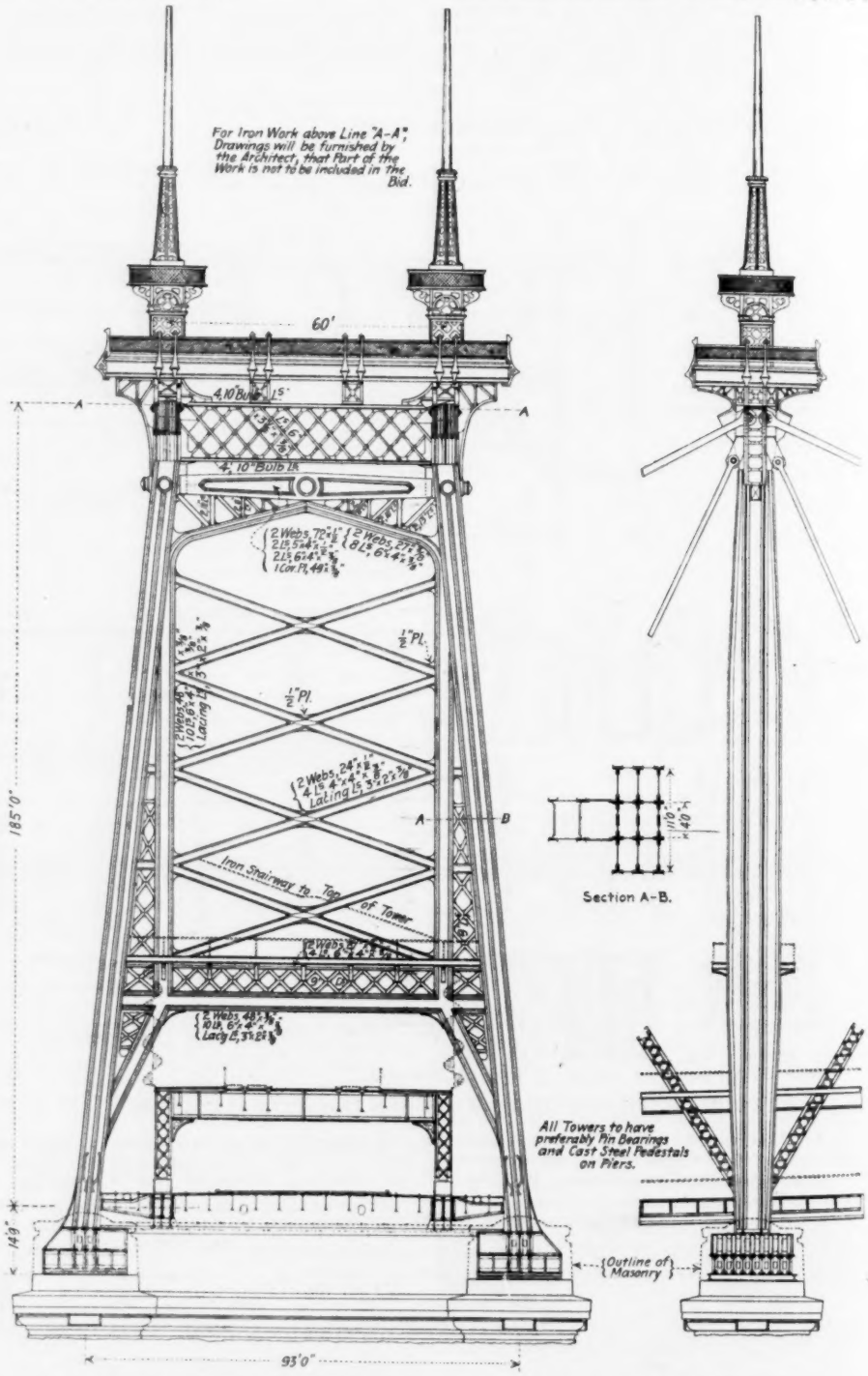


FIG. 4. SIDE AND END ELEVATION OF TOWERS OVER PIERS.

The several pieces forming one built member shall fit closely together, and finished members shall be free from twists, bends or open joints. All abutting surfaces in compression members shall be truly faced for full and even bearings, when riveted up complete. The ends of riveted floor girders shall be faced true and square. The pitch of rivets shall not exceed 6 ins. in the direction of the strain, nor 50 times the thickness of the thinnest outside plate connected, at right angles to the strain. At the ends of compression members the pitch shall not exceed four diameters of the rivet. The distance from the edge of any pieces to the center of a rivet hole shall not be less than 1½ times the diameter of the rivet, nor exceed 8 times the thickness of the plate; and the distance between centers of rivet holes shall not be less than 3 diameters of the rivet. The diameter of the finished rivet hole shall not be more than 1-16-in. greater than the diameter of the cold rivet. In all riveted work over ⅞-in. in thickness, the holes shall be either drilled from the solid, and after assembling, reamed to full size, or shall be drilled from the solid after assembling. In riveted work in main sections of members of the trusses and towers, not more than ⅞-in. in thickness, and all other riveted work over ⅞-in. and not more than ⅞-in. in thickness, the holes shall be either drilled from the solid, or made with a punch of a diameter of 3-16-in. less than that of the cold rivet, and then reamed to full size after assembling; after reaming, the holes shall be smooth, showing that the reamer has everywhere cut the metal. No corroding fluid shall be used either in drilling or reaming.

In all riveted work of ⅝-in. or less in thickness, except in main sections of members of the trusses and towers, the holes shall be punched to full size. Slight inaccuracy in the matching of holes may be corrected with reamers. Drifting to enlarge unfair holes will not be allowed. Poor matching of holes will be cause for rejection. All holes for field rivets and bolts, excepting those in connections

for lateral and sway bracing, shall, after being punched or drilled as specified before be either enlarged to full size with twist drills to an iron template, or reamed to full size while the connecting parts are temporarily put together, and matchmarked before being taken apart.

All chips and fins shall be removed from all surfaces in contact. The burrs on all drilled or reamed holes shall be removed by a tool countersinking about 1-16-in. Riveted members shall have all parts well pinned up and firmly drawn togeether with bolts before riveting is commenced. Rivets shall be driven by pressure tools wherever possible. Pneumatic hammers shall be used in preference to hand driving. Rivet heads shall be of approved shape, full and of equal size, and shall look neat and finished. They shall be central on shank and grip the assembled pieces firmly. Recupping and calking will not be allowed.

Loose, burned or otherwise defective rivets shall be cut out and replaced. In cutting out rivets great care shall be taken not to injure the adjacent metal. If necessary, they shall be drilled out.

Wherever bolts are used in place of rivets which transmit shear, the holes shall be reamed parallel and the bolts turned to a driving fit. A washer not less than ⅛-in. thick shall be used under nut. The use of bolts shall be avoided whenever practicable, and will be allowed only in minor details. When used they shall be thickly coated with paint so as to seal the hole against moisture. All nuts shall be of hexagonal shape.

All pins shall be accurately turned to gage, shall be straight and smooth and entirely free from flaws; they shall be bored through their axis with a hole of 2 ins. diameter. The clearance between pin and pin hole shall be not more than 1-32-in.

The widths of eye-bars shall not be less than the diameter of the connecting pins. The heads of eye-bars shall not be less in strength than the body of the bar and shall have an excess of cross-section through the pin hole of at least 30%. The heads of forged eye-bars shall be made by upsetting, rolling or forging into shape. No welds will be allowed. The heads shall not be more than 1-16-in. thicker than the body of the bar, and shall be neatly finished to the size and form given on approved drawings. Bars of the same width on the same pin shall not vary in diameter of head by more than ½-in. The bars shall be perfectly straight before boring, and the holes shall be in the center of the head and on the center line of the bar. Pin holes shall be bored smooth and straight at right angles to the axis of the member and parallel to each other. No variation will be allowed from the required lengths between centers of pin holes, exceeding 1-64-in. for every 40 ft.

Bars which are to be placed side by side in the structure shall be bored at the same temperature, and shall be so nearly equal in length that, upon being piled on each other, the pins shall pass through the holes at both ends at the same time without driving. Thimbles or ferrules shall be provided when necessary to keep the members in proper position on the pins. The anchor bars shall be provided with bronze bushings to obviate wear on pins from temperature movement.

Eye-bars, forgings, or members of important parts reheated, must be carefully annealed with pure heat, free from destructive gases, before being machined. The annealing of full-sized bars must be done with great care and with a pure flame, heating the bar throughout its full length uniformly, and to a temperature at which the steel shall become non-magnetic, and not over 75° F. above that temperature. It shall be held at this temperature only as long as it is necessary to acquire a uniform heat, and it shall be allowed to cool in the furnace to 570° F. for a time not exceeding 24 hours or less than 12 hours. All steel castings shall be annealed in a like manner.

Buckled plates shall be of approved form and size, ⅜-in. thick, and as many buckles to a plate as practicable. They shall be laid concave upward, and have a hole in the crown for drainage purposes. They shall be properly spliced and stiffened when necessary, and all details and connections proportioned for transmitting shear from wind loads, and shall be properly secured by rivets.

PAINTING.

All material shall be received and painted under cover; and no painting, either at the works or in the field, shall be done in wet or freezing weather. All structural steel and iron before leaving the shop must be thoroughly cleaned of all mill scale, dirt and rust, by the use of small hammers, steel scrapers and wire brushes, and of oil by the use of benzine, and then receive one coat of red lead and boiled linseed oil. These materials must be brought to the work in their original packages and mixed in a revolving churn just before using, in the proportion of 33 lbs. of dry red lead to one gallon of linseed oil.

The red lead must be strictly pure, and shall contain at least 80% of true red lead (of the composition Pb_3O_4); the total amount of lead present shall not be less than 89%, of which not more than 0.1% shall be present as metallic lead. The color shall be clean and pure tint. The red lead shall be of the fineness that when washed with water through a No. 19 silk bolting cloth no more than 1% shall be left on the screen. The linseed oil shall be an absolutely pure boiled oil, containing no matters volatile at 212° F. in a current of hydrogen; it shall not contain any rosin or manganese. The oil shall be perfectly clear on receipt and no deposit shall form on standing, provided the oil is kept at a temperature above 45° F. The film left after flowing the oil over the glass and allowing it to drain in a vertical position must dry to the touch after 24 hours. All finished surfaces shall be coated with white lead and tallow before being shipped from the shop.

After the structure is in place, all mud and dirt that may have accumulated during the erection must be removed and all abrasions in the first coat of paint must be thoroughly brushed with a stiff wire brush and such places "touched up," and all bolt heads and location marks thoroughly painted with the paint, as described, and then all the steel and iron work shall be thoroughly and evenly painted with an additional coat of red lead and boiled linseed oil, of the quality stated, mixed in a revolving churn in the proportion of 33 lbs. of red lead to one gallon of oil, with the addition of ½-lb. of best lamp black (ground in oil) to every 100 lbs. of red lead used. The second field coat shall consist of red lead and boiled linseed oil, without lamp black.

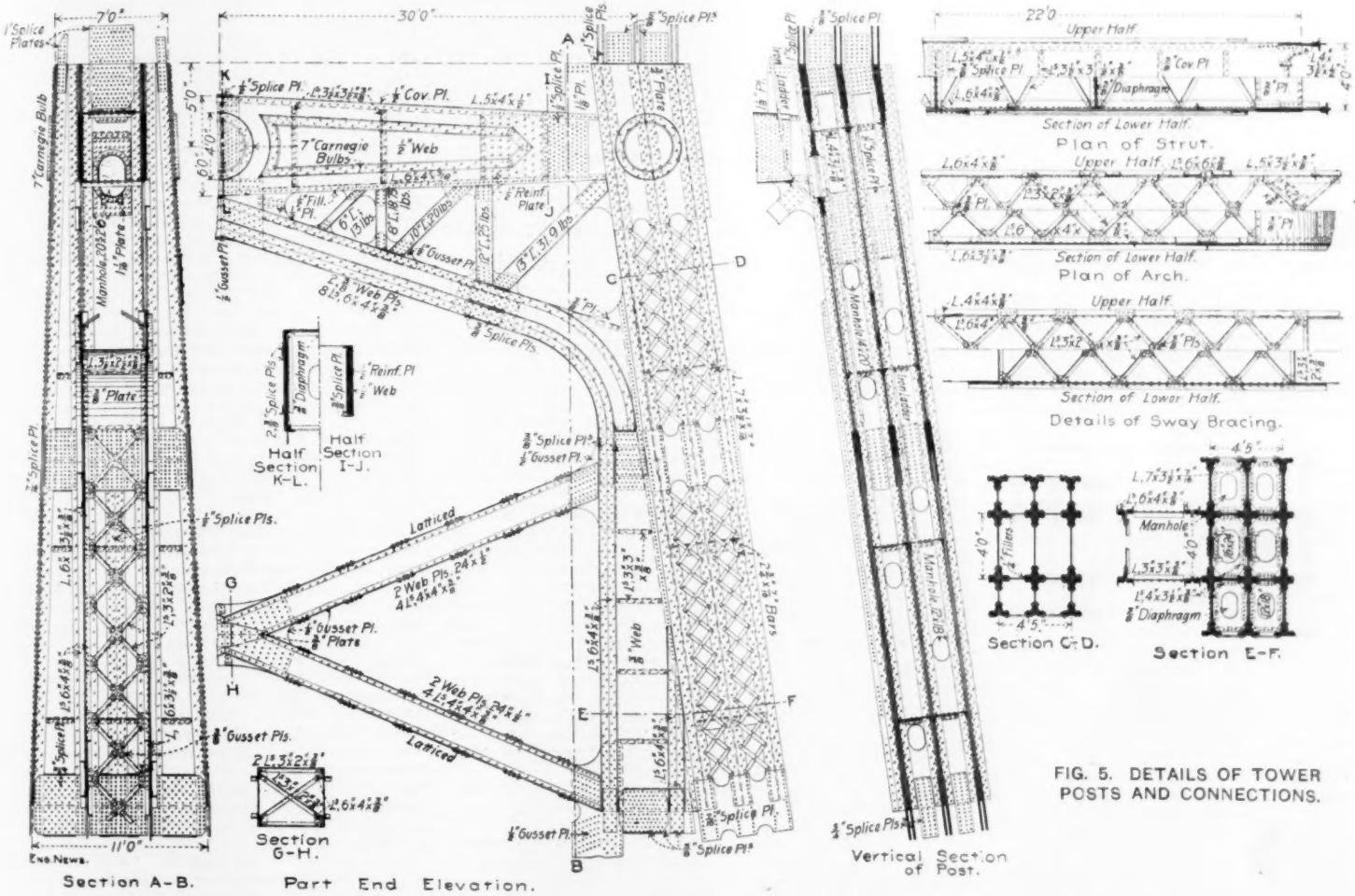


FIG. 5. DETAILS OF TOWER POSTS AND CONNECTIONS.

ERECTION.

The contractor shall provide temporary facilities to enable safe access to the work for inspection during erection. Finished material delivered at the bridge site shall be stored on skids at least 6 ins. above the ground, and in such a manner that there will be no exposed pockets or concave surfaces for collecting and holding water. The two shore spans and the island span will be erected on falsework, which shall be maintained in position until the two river spans are connected. The two river spans shall be built out without falsework or other obstruction to navigation.

All pins shall be supplied with steel pilot nuts, for use during erection. Anchor bolts for securing the superstructure to the masonry shall be furnished and set by the contractor as directed by the engineer. Suitable devices shall be provided at the anchor piers by the contractor for controlling the vertical and horizontal alinement of the trusses, so as to insure proper connection and adjustment at the center hinges of the river spans.

Suitable scuppers and drain pipes shall be provided at proper intervals along roadway and promenades. There shall be four expansion joints, one at each center hinge

and one over each anchor pier. Cross gutters of ample section and covered with cast-iron grating, shall be provided at these expansion joints, for proper drainage into pipes, care being taken to protect the steel work and masonry against wetting from drainage.

MOTOR AND DYNAMO FAILURES; THEIR NATURE AND CAUSES.*

By A. C. Cormack.

The three tables given herewith represent an analysis of the breakdowns which have occurred during the past four years to several thousand motors and dynamos, ranging in size from ⅛-HP. (motor) to 800 KW. (dynamo). The machines included in these statistics work under conditions of attention and superintendence which are somewhat better than the average, and since a number of very bad machines have been left out of the count, the figures must be taken to be considerably above the average. Motors driving coal-cutting machines have not been included, as the statistics from these are far from complete.

Table I. summarizes the nature of the accidents. When several parts were injured in a single breakdown, each is included in the table, excepting in those cases where the failure of one part is certain to follow on the failure of another. The points of origin of the different breakdowns are shown in Table II., and Table III. gives a summary of the ultimate causes of the failures. The per cents. in all cases refer to the total number of failures covered by the tables. The preparation of these tables has been somewhat complicated by the complex nature of some of the derangements. In some cases, the derangements were not caused by any single fault, and for this reason in preparing Table III. it was necessary to adopt a system of marks allocating the same number to each breakdown, but distributing them if more than one fault was the cause of breakdown.

Of the accidents in which the field magnet coils were damaged (Table I.), the larger number were cases in which the insulation between the coil and coil-former or cores had given way. The 1.56% representing coils gone altogether—that is, arcing from series to shunt on the same coil or arcing between two separate coils—show that this is not altogether an uncommon accident. The latter accident is most frequently met with in bipolar machines, where the coils often touch. In this case, unless the outer layers are at the same potential, there is considerable risk of accident.

The failure of armatures constitutes by far the most serious item on the table. The form which such failure most frequently assumes is the burning out of coils. In many cases the entire armature was burned out, and in others only a few coils. The percentage of coils gone to earth, 19.5%, is also a large item, and most of these failures were due to destruction of insulation. The accumulation of dust or other conducting matter on the insulating ridges, such as is met with at the end of the slot insulation or at the end of the coil supports of a barrel-wound armature, accounts for the majority of the remainder. Breakages of wire were confined mainly to the smaller sizes of wire-wound armatures, and usually took place at or about the points where the wires leave the coils or join the commutator. The joint failures are more common than they ought to be, although some were undoubtedly caused by short-circuiting in another portion of the armature. The 3.1% in which binders were burnt are those cases where fusing took place by arcing between the binder and armature wires, and did not arise from purely mechanical stresses.

Commutators are frequently damaged, this having occurred in 33.6% of the breakdowns. The failures of commutator-insulation have for the most part occurred at the ends, causing leakages to the earth-connected portions of the commutator or between bars or radial connections. In the majority of cases, these failures are caused by the presence of dirt, or other foreign matter, on the insulating ridges or between the radial connections. The mechanical failure of commutators, amounting to 10.95%, consists of burst commutators, fracture of commutator-lugs, and failure of keying of commutators. The cases where surface-fusion of the commutator has occurred are cases where the surface of the commutator has been destroyed by violent sparking, sometimes between segments, the latter fault being the usual accompaniment of a broken wire.

TABLE I.—Relative Frequency with which Various Portions of Dynamos and Electric Motors were Damaged in Breakdowns.

	Per cent.
Mechanical portions:	
Broken shafts	2.35
Binders and fasteners	9.40
Bearings	8.60
Other mechanical parts	4.70—25.05
Brush-gear, connections, terminals, etc.:	
Failure of brush insulation	2.35
Connections and terminals	3.10
Mechanical portion of brush-gear	1.56— 7.01
Field magnet coils:	
Coils burnt out	5.50
Coils earthed	3.10
Coils gone altogether	1.56—10.16
Armatures:	
Coils short-circuited and burnt out	29.00
Coils earthed (that is, failure of insulation of frame)	19.50
Breakage of wire	15.60
Joint failures	8.60
Binders burnt	3.10
Driving horns	2.35—78.15
Commutators:	
Failure of insulation	10.15
Mechanical failures	10.95
Surface fusion	12.50—33.60

TABLE II.—Points of Origin of Breakdowns. The Percentages given show the Frequency with which the Various Parts caused Breakdowns.

	Per cent.
Mechanical portions:	
Shafts	0.78
Bearings	8.60
General	1.65—11.03
Brush-gear, leads and terminals:	
Mechanical	3.90
Insulation	2.35
Leads and terminals	2.35— 8.60
Field magnets:	
Failure of coil insulation	7.80
Breakage of wire	0.78— 8.58
Armatures:	
Core and slot insulation	12.50
End insulation (that is, separating bridges)	5.50—18.00
Coil insulation	11.70
Joints	7.00
Fasteners and binders	1.65
Binder insulation	7.80
Driving horns	1.65—47.80
Commutators:	
Insulation	9.40
Fastening and keying	5.50—14.90
Starters	4.70
Unknown	3.13
Various	1.66

TABLE III.—Causes to which the Failures were Due.

	Per cent.
Constructional:	
Bad design	18.36
Perishing of insulation	7.40
Bad workmanship	13.60—39.36
Conditional:	
Overloading	1.37
Over-rating	1.66
Unsuitable	0.78— 3.71
Maintenance:	
Dust and damp	7.40
Rough usage	1.56
Defective attention other than above	22.50—31.46
Accidental and unavoidable, with reasonable care in construction and working	7.05
Unknown	13.10
Caused by faults in accessories	5.48

Table II. is interesting as showing the parts of the machines which originated the failure. Breakdowns to shafts were caused generally by the armature coming out of center through wear of the bearings, so that the unbalanced downward magnetic pull added to the weight of the armature produced a severe bending moment in the shaft. These cases are properly chargeable to the bearings. An interesting defect in dynamo and motor bearings, which sometimes occurs and requires watching to prevent damage, is the wearing of the bearing upwards. This sometimes occurs in cases where the armature has been placed nearer the top of the race than the bottom, in order that the upward pull of the magnets may relieve the pressure on the bearings. When the upward pull of the magnets is greater than the gravitational attraction, the bearings wear upwards, and allow the armature core to approach the pole-tips when working. This, owing to its liability to escape detection, is a somewhat dangerous defect, for when the machine is examined at rest the armature clearance will appear satisfactory.

Most of the joint failures in wires are caused by bad workmanship. They have been, for the most part, confined to one or two makes of machines. Unfortunately, if a faulty joint is nicely finished outside, it is very difficult to detect until it causes trouble. This usually begins on the commutator surface. A number of joint failures are due to improper fastening of the commutator, but such have not been included in the percentage.

Commutators are responsible for 14.9% of the breakdowns, and there may be divided into two classes. The first, in which the insulation has broken down, most frequently occurs between the bars and supporting rings, the parts subject to the greatest difference of pressure. Such breakdowns often result in the burning out of the armature windings. To a much slighter extent breakdown of insulation between the segments occasionally occurs. This seldom results in more than a few coils being damaged. Only in a very few cases does a breakdown occur in the body of the insulation, permitting flashing through it. These few cases have all occurred where a material which absorbs moisture has been substituted for mica. Almost all the accidents to commutator insulation are due to the collection of oil, dust, etc., on the insulating ridges separating the segments from the clamping nuts. In many cases these ridges are made much too short. Sometimes there are no ridges at all, the insulation being flush or even sunk below the level of both bars and rings. The insulation at the outside end is usually most exposed to such accumulations, but being more easily cleaned fewer breakdowns appear to occur here than at the back end where cleaning is very difficult, sometimes impossible. Very few cases have occurred where insulation has broken down owing to the commutator-wedging arrangements slacking back and permitting sufficient chattering to pulverize the insulation. This usually causes sufficient sparking at the brushes to draw attention to the defect before more serious mischief occurs. Defective fastening and keying of the commutator has caused 5.5% of the total number of accidents. Defective fastenings sometimes, although rarely, cause breakdowns of insulation, as described in the previous paragraphs. Bursting of the commutator by centrifugal force is not now so common as it used to be, and few cases are met with. As a general rule, the proportions of the parts are sufficient to resist the simple centrifugal stresses, and most of the bursts usually met with have been caused by improper locking arrangements. A cause of bursting of commutators which does not figure at all in this table is the bursting of the commutator owing to the bars being allowed to wear down too far. The defect or absence of keying of the commutators has caused in this class the largest number of breakdowns. When the keying is defective, the commutator is driven by the armature wires, and sometimes the commutator and the armature have slight relative motion on the shaft. This has caused a large number of breakages of the wires joining the armature to the commutator.

Starting switches of motors have been the cause of 4.7% of the breakdowns in the table, and the writer may say that this figure has been kept low by timely alterations to a number of dangerous switches. A not uncommon fault in starters which has caused burning out of armatures is a breakage of the wire near the last stop. In such cases, a careless attendant occasionally continues the use of the starter, subjecting the armature to very heavy starting currents by applying practically the full voltage to a standing armature. In this connection may be mentioned another very common fault which is found in starters for shunt motors—that is, taking the connection from the last stop of the resistance. This results in the voltage applied to the shunt at the moment of switching on being lowered to the same extent as the voltage applied to the armature, with the result that, to get the necessary starting torque, the full-load current has to be much exceeded. The starting torque can be kept up by attaching the shunt-wire to the first stop in the resistance. When the switch is in the "on" position, the current for the shunt requires to flow back along the resistance, but, as a general rule, this is a matter of little importance, and where it is desirable to arrange otherwise, an additional stop can be put in the switch to cut out this resistance after the lever has reached the last stop.

Table III. sets forth as far as possible the conclusions reached as to the cause of breakdowns. Some of the headings in this table mean practically the same thing, but it seemed desirable to make out separate categories. For example, the heading "Dust and damp" might have been merged in the "Defective attention" heading; but a number of breakdowns have been caused by dirt and damp that could hardly have been attributed to defective attention on the part of the attendant.

The first of the main headings, "Constructional defects," is responsible for 39.36% of the total number of breakdowns. With greater laxity in supervision, resulting in a greater number of breakdowns, this heading would probably have been a smaller percentage. A number of the defects in design, construction, etc., were known to exist when the machines came under observation, but they were usually of such a nature that little could be done to remedy them without entirely reconstructing the machines. Almost half of the 39.36% of the total failures were due to bad designs, 7.4% to deterioration of insulation under normal conditions of working. The writer looks upon this latter as bad design, because it is the use of unsuitable materials or of materials under unsuitable conditions.

Comparatively few of the faults were found in the mechanical portions of the machines. Those usually took the form of insufficient keying, bad arrangement of bearings, and other defects familiar to all mechanical engineers. The great majority of the faults in design appear to be in the electrical portions of the machines, and for the most part take the form of supplying too little insulation, insufficient insulating ridges, improper arrangements for supporting the conductors and their insulation. The writer is afraid that, owing to the stress of competition, a number of designers sacrifice, to a great extent, reliability to cheapness. Particularly in the case of small and medium-sized motors the tendency is to design machines having higher rises of temperature than experience has shown to be compatible with reasonable durability of the machine. No margin appears to be left for the slightly abnormal conditions that almost every machine sooner or later meets with in its working life.

Damp and dust, 7.4%, refers to those cases where a reasonable amount of attention was given to the machines by the attendant, but where, owing to unfavorable conditions, it was not possible to keep the machine sufficiently clean and dry to prevent trouble. Dust is frequently somewhat hygroscopic, absorbing quantities of moisture. Defects from dust occur most frequently in semi-enclosed motors. These are splendid automatic dust bins; the provision for cleaning usually is insufficient; many of them cannot be cleaned properly without being taken apart, and it would in most cases be impracticable to do this every time the machine required cleaning. The defects in semi-enclosed motors might quite well be attributed to bad

*Abstract of a paper, entitled "Electric Plant Failures; Their Origin and Prevention," read before the British "Institution of Mining Engineers," 1903.

design or unsuitability, but the writer leaves the reader to place it as he thinks fit, with the advice to adopt, where necessary, wholly enclosed motors, large enough to run cool; and easily accessible open-type machines in all other situations.

STEEL CARS OF THE SIDE-DOOR TYPE FOR SUBURBAN TRAFFIC: ILLINOIS CENTRAL R. R.

With the growth of the suburban traffic of great cities there has developed a necessity for the means of handling this dense and concentrated traffic with increasing promptness, efficiency and safety. At the same time, a number of recent accidents have pointed very forcibly to the necessity

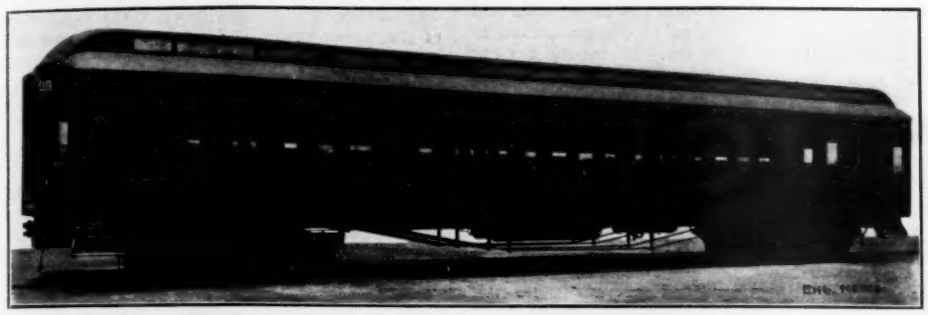


FIG. 1. STEEL-FRAME SIDE-DOOR SUBURBAN CAR; ILLINOIS CENTRAL R. R.

of fireproof construction of cars. The Illinois Central R. R. has recently made a striking departure from ordinary methods of car design and construction in introducing some experimental suburban cars of steel frame construction, having transverse seats and side doors. The seats, however, are of such length as to leave a gangway along each side of the car. The importance of these cars lies not only in their design and construction, but also and more particularly in the effect which their introduction may have upon the safe, rapid and efficient transportation of a dense passenger traffic, and the protection against fire which they afford.

The new cars were designed, as the result of careful study and long experience in handling heavy suburban traffic, by Mr. A. W. Sullivan, Assistant Second Vice-President, and Mr. William Renshaw, Superintendent of Machinery, Illinois Central R. R. To these gentlemen we are indebted for the material from which this article has been prepared. Fig. 1 is an exterior view of one of the cars, showing the side doors closed. Fig. 2 is an interior view, showing the central row of transverse seats (with steam heating pipes below the seats), and the gangway or aisle on each side.

The following has been condensed somewhat from a detailed description of the cars furnished to this journal by the gentlemen named:

During the few months of the Columbian Exhibition at Chicago, in 1893, the Illinois Central R. R. transported safely and with great facility some 19,000,000 passengers, most of whom were carried in side-door cars (Eng. News, July-Dec., 1892, p. 462). The experience then gained has been applied to the improvement of the regular suburban service, and to the development of the new steel-frame side-door car with wide vestibules.

The idea ordinarily suggested by the term "side-door car" is that of a car divided into separate compartments, in which the seats are arranged transversely, extending from side to side of the car, with no communication between the compartments, access to which is provided by doors swinging outward. This style of car is in general use in Europe and Great Britain, but offers no advantage over the end-door car used in America, as it is even slower in its operation. In fact, the disadvantage of the side-door car as used in England is so great, that serious consideration has been given there to the "end-door car" used in America, as offering means of relief from the difficulties now experienced.

The side-door car of the Illinois Central R. R is quite unlike that used on English railways, in detail as well as in principle. In the first place, the swinging door is discarded, and the danger to which passengers on the station platforms and in the car are exposed by doors opening unexpectedly when trains are in motion, is eliminated. Instead of these swinging doors, sliding side-doors are used, and these are operated and controlled by mechanism within the walls of the car. All the doors may be opened and closed together or separately, as occasion may require, by the trainman in charge of the car. This arrangement effects great saving in time over the swinging door method.

Next to the sliding door, the abolition of the interior compartments and the opening of side aisles are the most noticeable features. In English practice, when a train arrives, the intending passengers must go along the station platform, looking into the compartments until vacant seats are found. This proceeding consumes much time and often greatly delays the train. By the use of aisles extending the entire length on both sides of the car, as in the new Illinois Central R. R. cars, the passengers may enter at once any of the side-doors, and if vacant seats are not found immediately at the entrance, they can pass along the aisles to other parts of the car, or if necessary, through end-doors of the vestibules to other cars where seats may be found. The train having meanwhile started, no time is lost in waiting for passengers to find seats.

With the steadily increasing density of passenger traffic upon railways having a suburban business, and particularly upon the elevated and subway lines handling a heavy metropolitan traffic, the limitations of the end-door cars have become apparent, as demonstrated by the unreasonable detentions of trains at stations in discharging and taking on passengers during the rush hours of the morning and evening. These detentions have a material influence in diminishing the earning capacity of the properties, to say nothing of the inconvenience to the public occasioned by the inability of the lines to afford the requisite accommodations. The remedy usually applied of increasing the number of trains at such times does not afford the desired relief, for the reason that no improvement can thus be effected in the crowding of passengers at the ends of the cars, with the incidental surging, struggling efforts of many persons to gain immediate entrance through the narrow gateways and end-doors.

Under these circumstances it is evident that the remedy lies in preventing the formation of the crowded groups at the ends of cars, and of distributing the passengers evenly over the entire length of the station platform, so that when trains arrive they may step directly and conveniently from the platform to the side-doors of the cars. Such distribution can be effected only by the use of cars having such a number of side-doors that there is no choice of position on the station platforms when awaiting trains. This result is obtained in the new cars, which have 12 sliding side-doors on each side, spaced 5 ft. c. to c. throughout the length of the car. Each door is directly opposite a section of eight seats, with aisles on both sides just inside of the doors and extending the entire length of the car.

As between an end-door and a side-door car, the relative quickness of movement in receiving and discharging passengers is represented by the relation of the length to the width of the car and the number of doors available. In a car 60 ft. in length, with two end-doors, passengers may leave the car in single file at the rate of one per second from each door, requiring 30 seconds to empty the car. But in a car 10 ft. wide, with 12 side-doors, passengers may leave the car at the rate of one per second from each door, requiring but five seconds, or one-sixth of the time, to discharge the same number of passengers. In addition to the convenience, the fireproof qualities, and the impossibility of telescoping in case of collision, the new steel-frame car is from 6,000 to 10,000 lbs. lighter than cars of the same size of the standard wooden construction.

The underframe of the car consists of four 9-in., 21-lb. steel I-beams, 64 ft. long, spaced nearly

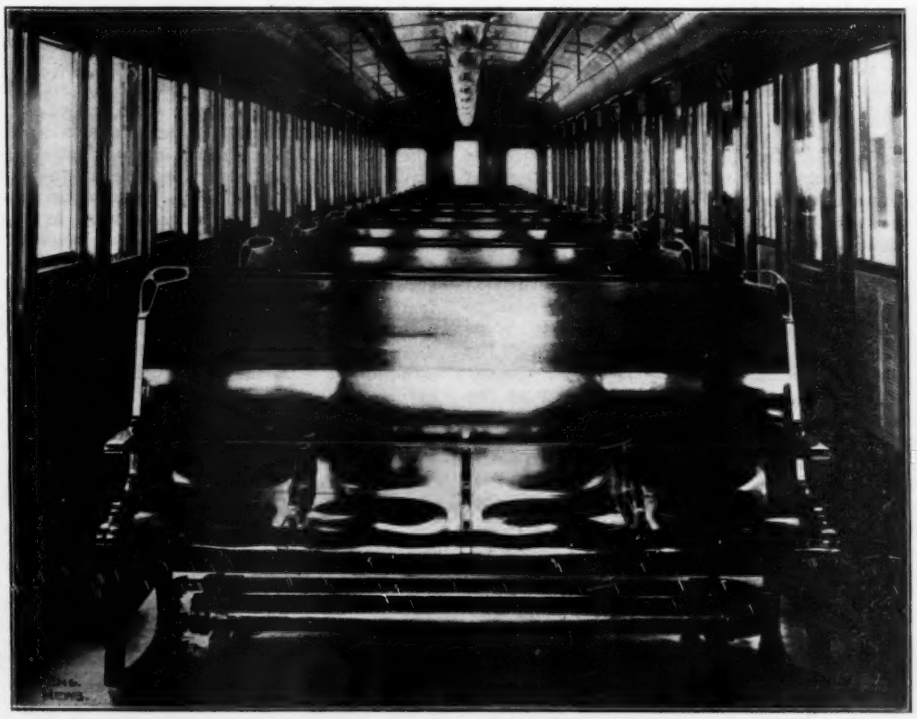


FIG. 2. INTERIOR OF NEW SIDE-AISLE SUBURBAN CAR; ILLINOIS CENTRAL R. R.

equal distances apart, the total width over the flanges being 10 ft. 4 ins. The end sills are 9-in., 25-lb., steel channels, set with their backs to the squared ends of the longitudinal sills and riveted to them with double angle plates reinforced by gussets. Four truss rods passing over the inner body bolsters and anchored to the outer body bolsters, are used to support the middle of the car. Each rod is continuous, without the usual turn-

buckle connection in the middle. The adjustment is effected by eight vertical screw queen-posts or struts resting with their lower ends upon the rods, while their upper ends support two needle beams of 7-in., 15-lb. I-beams extending across the car under the sills. These have their upper flanges riveted to the lower flanges of the sills, thus bracing as well as supporting the underframe. Over the body bolsters and over the needle beams are 6-in., 21¼-lb. I-beams in short sections, placed between the longitudinal sills as stiffening members and riveted with angles to the webs of the sills.

Upon the metal sills is laid a steel floor of ¼-in. plates, 60 ins. in width; the butt joints formed by the planed edges of the plates extend entirely across the underframe. This floor is riveted to the upper flanges of the sills with double rows of ½-in. rivets. There is thus obtained a continuous metal surface extending the entire length and width of the car, insuring perfect rigidity of the underframe and giving complete protection from fire underneath the car. The underframe has four body bolsters made of steel bars, 1 × 7 ins., in the upper and lower members. The bolsters are in pairs, 4½ ft. c. to c., and are bolted to the lower flanges of the sills. Heavy truss connections extend between the bolsters, to which are bolted the center plates.

The cars have four-wheeled trucks of the railway company's standard construction for passenger service, with 33-in. rolled steel wheels, and steel axles having journals 5 × 9 ins. The cars are equipped with the standard steel platform and couplers, and the Sessions friction draft gear. A novel method of attaching the draft rigging to the car has been adopted in consequence of the wide distance (38 ins.) between the center sills. A steel plate, ¾ × 29 × 42 ins., is placed between the main sills of the underframe and the sub-sills of the platform and bolted through their flanges with 24 bolts, ⅝-in. diameter, accurately turned to enter reamed holes with a driving fit.

The upper framing is of steel. The exterior finish is of poplar, in vertical tongued-and-grooved strips 2½ ins. wide. The interior finish is of mahogany, while the roof is of 13-16-in. poplar, covered with canvas and painted. Upon the steel plate floor already described is a ¼-in. layer of asbestos, covered with a wooden floor of transverse strips of maple, ¾ × 2¼ ins., bolted to the steel floor. This construction is not only fireproof, but will not become uncomfortably cold in winter.

The interior of the car is open throughout its entire length to the end platform sills of the vestibule, the floor of the car and the vestibules being continuous. The platform lids which cover the steps open against the ends of the car, and the vestibule side-doors swing across the ends of the side aisles to prevent passengers from walking into the opening for the vestibule steps. Provision is made in the seating arrangements for a passage around the vestibule side-doors, so that the steps can be approached in the usual manner when the vestibules are used by passengers leaving the car at places where the station platforms are on the ground level. The vestibules are also provided with swinging end-doors.

The seats are of an entirely new design, in bench form, arranged transversely in sections, each section seating eight passengers. They are constructed throughout of mahogany, with straight backs 42 ins. high, provided with swell panels for back rests. No upholstering is used. The seat bottoms of solid mahogany are of molded form, mounted on trunnion bearings in front and supported on springs in the rear. Each passenger has an independent seat, separated from adjoining seats by short arms. There are twelve sections of seats, with two additional seats at each end of the car, making a total of 100 seats.

Between the seat ends and the wall on each side of the car is an aisle 18 ins. wide, extending the entire length of the car and connecting with the vestibule. Opposite each seat section and directly in line with the transverse or section aisle is a side-door on each side of the car, making a total of 24 side-doors, 12 on each side. The doors are mounted at the top on ball-bearing rollers and slide in and out of the spaces in the walls of the car. The thresholds are flush with the floor, equipped with safety treads and grooved to receive the lower ends of the doors. These doors are connected by mechanism concealed within the hollow walls of the car, and arranged to be operated in series by compressed air or by hand. The pneumatic apparatus is found to work admirably. The controlling mechanism is located at the ends of the car, and is operated by the trainman. The mechanism is arranged so that the doors can be operated by either of two systems: (1) that of the positive opening, closing and locking of all the doors on a side at one time; or, (2) the closing, locking and unlocking of all the doors at one time, leaving the opening of such doors as are to be used to be done by the passengers from either the inside or outside of the car.

Each door is provided with a sliding sash and blind, the maximum opening of the glass sash in the doors being 21 × 30 ins. To insure a tight joint when the sliding side-doors are closed, the front edges of each door are beveled and trued to fit closely into similarly beveled edges of the door strips, making an air-tight fit without the aid of weather strips. At the rear the square edges of the doors are made to fit closely by strips of plush or felt, which also prevent rattling.

The unusual height of the sides has made it possible to carry the glass in the doors and windows to a height of 6 ft. above the floor, thus giving an outside view to standing passengers without the necessity of stooping. Another convenient feature resulting from the use of side aisles is in the arrangement of the roller shades and blinds in the windows and doors. In their drawn position these leave exposed a strip of the window glass 10 ins. high and extending the entire length of the car, on the line of vision of the seated passengers, so that a clear view of the outside can be had at all times of the day without exposing the passengers to the direct rays of the sun. The deck sashes are fitted with opalescent glass and are operated in series by means of levers, one at each corner of the deck.

The ceiling of the lower deck is in hinged sections 5 ft. long, to admit of ready access to the door-operating mechanism. The moldings forming the upper and lower edges of the movable ceiling panels also serve as racks for the display of advertising cards.

The Pintsch gas system is used for lighting, the lamps being about 16 ins. lower than usual, to give a better distribution of light for reading. This arrangement is made possible by placing the lamps over the backs of the seats, out of the way of passengers using either the side or cross aisles. There is one 3-burner lamp for each section. For heating, the direct-steam system of the Safety Car Heating & Lighting Co. is used, with pipes arranged under the seats, as shown in Fig. 2. Special attention has been given to avoid the pocketing of heated air under the seats, and to insure free circulation in order to maintain an even temperature throughout the car. Ventilation is secured by adjustable sashes in the upper deck and by sliding sashes in the side-doors. The car is equipped with the Westinghouse quick-action automatic air-brake.

The general dimensions of the cars are as follows:

Side-Door Suburban Cars; Illinois Central R. R.

Length over couplers	71 ft. 11¼ ins.
Length over end sills	64 " ½ "
Width of sheathing	10 " 6 "
" inside	9 " 6½ "
" over roof	10 " 8 "
Height, rail to floor	4 " 2 "
" " " bottom of sills	3 " 4 "
" " " top of side	11 " 6 "
" " " top of roof	14 " 3 15/16 "
Door openings (12 each side)	6 ft. 7 ins. × 2 ft. 2 ins.
Seats	6 ft. 5 ins. × 2 ft. 9 ins.
Space between seats	2 ft. 3 ins.
Width of side aisles	1 " 6¾ "
Wheels	2 " 9 "
Wheelbase, truck	8 " 0 "
Wheelbase, total	56 " 0½ "
Trucks, distance, c. to c.	48 " 0½ "
Weight of body	61,400 lbs.
Weight of trucks	23,200 "
Weight, total	84,600 "
Seating capacity	100 passengers.

WATER POWER DEVELOPMENT ON THE CHICAGO DRAINAGE CANAL AT LOCKPORT, ILL.

The utilization of the water power of the Chicago main drainage canal has many times been proposed, and the project has been discussed in our columns. The fact that definite steps have now been taken towards the construction of the works necessary for water power development was noted in our issue of Aug. 20, and we are indebted to Mr. Isham Randolph, M. Am. Soc. C. E., Chief Engineer of the Sanitary District, for further particulars of the work. This development is to be at Lockport only. It has been reported that it included Joliet also, but this, we are informed, is a mistake, as the Sanitary District has not yet secured all the property necessary for the carrying out of the maximum possibilities of the development. Bids are now being invited for the construction of the head-race and tail-race.

The carrying out of the plans for the utilization of this water power was made possible by the passage of a law at the last session of the Illinois Legislature, which provided for the development of the water power at Lockport, Ill., and enabled the Trustees of the Sanitary District to levy and collect in each year, for a period of three years, a tax not exceeding 0.25% of the value of the taxable property within the corporate limits of the District for the payment of the cost of such development.

The plans prepared by Mr. Randolph, the Chief Engineer, and adopted by the Board of Trustees, provide for the extending of the main channel from the present controlling works south about 10,500 ft. to the location of the power house. This extension or head-race will have a minimum width of 160 ft., and a grade on the bottom of 1 in 20,000, in continuation of the grade of the channel north of the controlling works. As the natural surface of the ground varies from 15 to 30 ft. below Chicago datum it is necessary to impound the water of the head-race. This is to be accomplished by constructing on the east side a concrete retaining wall of natural cement with a Portland cement facing, reinforced by a rock fill 44 ft. wide on top, with a 1 to 1 slope on the easterly side; on the west side will be a levee of rock with an earth core, but where the height demands it this core wall will be of concrete. The tail-race is to be a channel of the same dimensions as the completed channel, and is to extend about 7,000 ft. to a junction with the Desplaines River. The river channel is to be deepened for a width of 160 ft. to afford a minimum depth of 10 ft. through to the upper basin at Joliet.

At the east of the power-house site a lock 22 × 130 ft. is to be constructed to enable boats to pass from the Illinois & Michigan Canal into the head-race. This is provided for the reason that that part of the Illinois & Michigan Canal between Joliet and Chicago will be abandoned upon the completion of the water-power development. A bear-trap dam for the regulation of the flow in the channel, and for the removal of ice and debris, is also to be constructed between the power house and the lock.

The power house is to be constructed of concrete and brick. It is to have ten turbine chambers; seven for power units and three for exciter units. The power units are each designed to pass 100,000 cu. ft. per minute at 0.8 discharge. They are to consist of turbines on horizontal axes, capable of generating 6,500 HP. with gate fully open under a 34-ft. head, and at 150 revolutions per minute. Each power unit is to drive one three-phase 2,200-volt generator of 3,750 KW. The number of cycles has not yet been determined.

As the ultimate discharge of the canal will be 600,000 cu. ft. per minute, it will be seen that six units at 0.8 discharge will utilize the whole flow. The seventh is added so that one may be held in reserve to take the place of any unit laid up for repairs. Two of the exciter units are also sufficient to furnish the proper excitation. Each unit is to be provided with a ground and electric speed controller, and the generator room is to be provided with an electric traveling crane of 50 tons capacity.

COVERING STEEL PROPELLER BLADES with thin sheet brass or copper to protect them from corrosion has been successfully accomplished by Mr. John Lyall, Superintending Engineer for Cayza, Irvine & Co., England. As illustrated in London "Engineering" the sheathing is closely bedded to the surface beneath with specially constructed joints at the leading and following edges of the blades. A considerable number of steamers of the Clan line have had their propellers thus sheathed and have shown considerably better speeds with less coal consumption than sister vessels fitted with cast-iron propellers.